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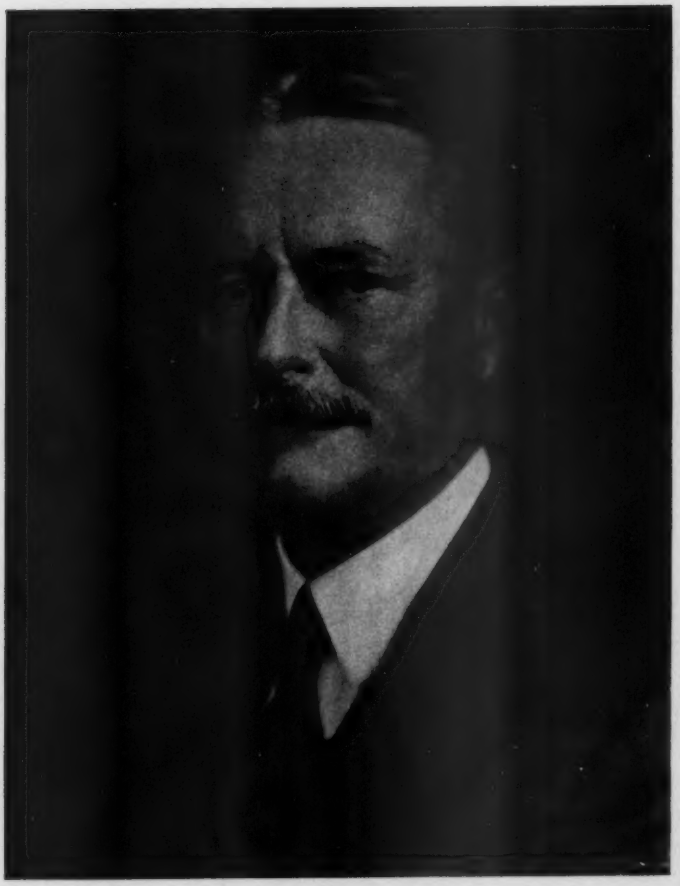


DOUGLAS SMITH ANDERSON

DOUGLAS SMITH ANDERSON

President Anderson was born at Lexington, Virginia, September 6, 1871. He graduated from Washington and Lee University in 1890 with the A.B. degree, and received his M.A. degree from Tulane University in 1892, specializing in Physics and Electrical Engineering. He subsequently took special work in Physics at the University of Berlin and at Zurich Polytechnic School. He received the honorary degree of Doctor of Science from Washington and Lee University in 1933.

Appointed Assistant Professor of Physics at Tulane University in 1892, he served in that capacity until 1896, when he was promoted to Associate Professor of Physics and Electrical Engineering. He was Professor of Electrical Engineering at the University of Mississippi for the session of 1900–01. Returning to Tulane University in 1901 he became Associate Professor of Electrical Engineering when that department was separated from the department of physics. He was promoted to Professor and head of the department in 1914 and was made Dean of the College of Engineering in 1919, in which capacity he still serves.

During the World War he organized and directed the Electrical Division of Tulane University's School of Radio Operators and Automobile Mechanics, in which several thousand men were trained for over-seas service.

Dean Anderson's professional career has been devoted almost entirely to teaching and administrative work, and he bears sincere testimony to the inspiration and encouragement which he has always received from the activities of the Society for the Promotion of Engineering Education, of which he has been a member since 1900.

Owing to the illness of President Dinwiddie, Dean Anderson was appointed Acting President of Tulane University for the session of 1933–34.

He is a member of Phi Beta Kappa, Sigma Phi Delta, Phi Phi, Omicron Delta Kappa, The American Institute of Electrical Engineers, the Louisiana Engineering Society (Past President) and a Fellow of A. A. A. S. A member of the S. P. E. E. since 1900, he served on the Council 1926–29, was Vice-President in 1931–32, and has been a member of various committees.

William Elgin Wickenden

WILLIAM ELGIN WICKENDEN, President, Case School of Applied Science, Cleveland, Ohio, awarded the eighth Lamme medal by the Society for the Promotion of Engineering Education at its forty-third annual meeting at Georgia School of Technology, Atlanta, Georgia, June 26, 1935.

President Wickenden was born in Toledo, Ohio, December 24, 1882. After graduating from Denison University, Ohio, in 1904, he entered upon his teaching career as instructor in physics at Mechanics Institute, Rochester, New York. The following year he became Assistant in Physics at the University of Wisconsin and later transferred to the department of electrical engineering. In 1909 he became Assistant Professor, and in 1914 Associate Pro-

fessor of Electrical Engineering at Massachusetts Institute of Technology. From 1918 to 1921 he was Personnel Director of the Western Electric Company, was appointed Assistant Vice President of the American Telephone and Telegraph Company in 1921, in 1924 resigned to become Director of the Investigation of Engineering Education for the Society for the Promotion of Engineering Education. He was elected president of Case School of Applied Science in 1929.

As a teacher, personnel manager, and educational administrator his entire career is characterized by unusual clarity of perception and expression. These qualities have given distinction and exceptional value to the report of the investigation of engineering education, the final volume of which was published last year. The manner in which the investigation was conducted is not only a tribute to his technical ability but shows unmistakably the influence of his administrative genius upon a major survey of educational activities.

He was elected a Member of the Council of the Society in 1924, and in 1933, President. He is the author of a book on Illumination and Photometry. He was Regional Supervisor of Personnel Methods, S. A. T. C., 1918. In recent years he has served as a Director of the Adult Education Association of Cleveland, a Trustee of Cleveland College, President of the Ohio College Association, and consulting member of the Committee on the Improvement of College Teaching of the A. A. U. In civic activities he has served as a Director of the Cleveland Community Fund, Director of the Cleveland Chamber of Commerce, Vice-President of the Cleveland Welfare Federation, Chairman of the Ohio Labor Board and Chairman of the Ohio Highway Survey Committee. He is a member of the Association for the Advancement of Science; American Society of Mechanical Engineers; American Institute of Electrical Engineers; American Association of Political and Social Science; Cleveland Engineering Society; and Cleveland Community Fund.

He is also a member of Sigma Chi, Phi Beta Kappa, and Sigma Xi. Honorary degrees bestowed upon him are: Doctor of Engineering, Lafayette College, 1926, Worcester Polytechnic Institute, 1927, Case School of Applied Science, 1929, and Rose Polytechnic Institute, 1932; Doctor of Science, Denison University, 1928, and Bucknell University, 1930; Doctor of Laws, Oberlin College, 1930; and Doctor of Humane Letters, Otterbein College, 1933.

RETROSPECT AND PROSPECT

By DOUGLAS ANDERSON, *President of the Society*

History repeats itself, with variations. Once again the fair city of Atlanta has been besieged by the hosts of the North, East and West, this time in friendly contact with the hosts from the South, holding a convention of the greatest significance to the educational interests of the section designated by President Brittain as the "Deep South." While the Society has met twice before below the line of Mason and Dixon, the Forty-third Annual Meeting was its first venture into a part of the country which our northern friends are wont to think of as being unendurably hot during the last week of June.

But Atlanta and Georgia Tech were on their mettle and had evidently issued quite definite orders to their weather man, for he gave the convention four days of weather far more comfortable than that experienced by us on several occasions in the far north and the middle west. One is almost tempted to hope that the S. P. E. E. may sometime be induced to come to that most unique of American cities, New Orleans.

The election to the presidency, for the first time in the history of the Society, of a representative of a southern institution was a graceful and generous gesture in recognition of the efforts and the progress of the South in the development of engineering education. With an attendance of 700 from 132 institutions and societies of this country and Canada, the meeting was a success from every point of view. If any criticism might be voiced as to the program, it would be that there was an embarrassment of riches. There was a noticeable absence of discussion from the floor at the general sessions, due perhaps to the fact that almost the whole of the time at each session was consumed in the reading of prepared papers or reports. There was interesting and valuable material in many of the separate conferences which might well have been presented at the general sessions. As the administrative officer of a college of engineering the writer found himself wishing that he might be in several places at the same time with sufficient mental capacity to absorb some of the valuable ideas being discussed in these conferences.

Next June the great University of Wisconsin and the lovely little city of Madison! These names conjure up pleasant recollections to those of us who attended the meeting of deans and adminis-

trative officers in 1933, immediately following the annual meeting in Chicago. Aside from the meeting itself, the University, with its beautiful campus on the shores of Lake Mendota, will afford much of interest to our members, and we shall all join with the greatest of pleasure in doing honor to that distinguished pioneer of engineering education, Dean Turneaure.

The writer once heard a statement to the effect that the great success of the University of Wisconsin was due in no small measure to the fact that from its early inception the institution has studied diligently the needs of its state and its section of the country and has developed its work scientifically and practically to meet these needs.

This same idea lies back of the activities of the S. P. E. E.—the constant study of how our schools of engineering may best prepare their graduates to meet the problems of our rapidly changing social and industrial conditions, in the solution of which they are to be such important factors. One has the feeling, each time one comes away from an annual meeting, that we have done much and, at the same time, left much undone. That is a mark of true progress. Committees will be busy throughout the year and there will be much new material to be added to their findings and presented at the Wisconsin meeting.

And by no means the least interesting of these will be the new problem of accrediting engineering colleges. While the actual agency for this accrediting is to be the Engineers' Council for Professional Development, the problem is one of the greatest importance to the S. P. E. E., but one which the Society has very wisely refrained from attempting to handle itself, biding its time until there should have been developed a competent organization like the E. C. P. D.

THE NEW EPOCH IN ENGINEERING EDUCATION*

By C. C. WILLIAMS

President, Society for the Promotion of Engineering Education; Dean, College of Engineering, The State University of Iowa

One of the time-honored tenets of philosophy is that the affairs of this universe consist of causes and effects, that a phenomenon is always followed by an effect, that there is never an event without a cause, and that an effect is commensurate with its cause. To the extent that this tenet is valid, we may reasonably expect a disturbance so catastrophic in its proportions as the present great depression to produce momentous effects in those spheres which it touches. The extent to which engineering, and indirectly, engineering education, may be modified is a matter that may well engage our attention. Recognizing the urgency of this question as well as the responsibility of this Society for the answer, your program committee pointed the deliberations of this annual convention to the theme "Looking Ahead"; and in order to divert discussion in that direction, I purpose at this time to comment on two aspects of the matter, viz., (1) The adjustment in curricula to suit new conditions, and (2) the probable status of engineering education in the post-depression era.

Insofar as educational processes consist of cultivating the student's power to think and his facility in expressing his thoughts, the results are applicable in any environment, and happily the bulk of the education process is of this enduring character. However, because the transfer of mental disciplines is limited, and because applied science offers as good exercises for thinking as does ancient lore, in addition to storing the mind with usable information, engineering education employs practical science in its processes. Hence, it is not of the cloister, but of the world of affairs—"a product of industrial, social and political life and ideals," to quote Professor Scott's admirable report. Furthermore, in recent decades, the engineering profession has been gradually shedding its strictly technical chrysalis and emerging as one of the dominant influences in shaping economic affairs, and every new application of mechanical energy extends the circuit of its influence. Engi-

* Presidential Address delivered at the 43d Annual Meeting, S. P. E. E., Georgia School of Technology, Atlanta, Ga., June 24–27, 1935.

neering education has been so drawn out of its isolation that the absence of change in the pattern following the crises of '73, '93, and '07 does not prove that none will occur now. On the contrary, from the present paralysis of economic agencies and clogging of economic channels, engineering education can scarcely escape modification with regard to its social attributes, even though it should remain unaltered as individual scientific training.

If before proceeding with any forecast of the new epoch, we glance back for a moment at the mileposts of the past in order to find the measure of an epoch, we observe that the century covering the development of engineering education in America is divided naturally by certain notable events into three fairly equal periods, each of which exhibits rather distinctive characteristics.

The first epoch would be placed readily as the interval between the founding of engineering instruction at West Point and Rensselaer, about the close of the first quarter of the last century, and the passage of the Morrill Act in 1862. It may be called the "Epoch of Beginnings." The second epoch extends from the Morrill Act to the founding of the first engineering experiment station in 1903, and may be given the caption "Curriculum Building." In this period, the undergraduate curriculum took form and the main branches of engineering became differentiated and recognized; the scope and character of engineering were essentially determined by men in field and shop, the professor endeavoring to impart a knowledge of practice to his students as best he might; the required preparation for the engineering instructor beyond graduation consisted of practical experience in field or factory; and graduate study was almost unknown because four years brought the student to the limit of engineering knowledge as presented in the textbooks.

The third epoch spans the interval between the first experiment station in 1903 and the present great depression, and may be called the "Epoch of Research." In this period research profoundly affected engineering education, both as to underlying philosophies and as to procedures. Effort to teach engineering practice was largely discontinued, emphasis being shifted to fundamentals and to the research method of approach. Engineering became investigative as well as applied science. In fact, during the last two decades of this epoch, investigations in engineering laboratories have been so comprehensive and thorough that frequently the research potential has actually been higher at the applied science pole than at the pure science, or "curiosity pole," with the result that the current of new knowledge has flowed from the former to the latter about as often as in the reverse direction. Experiment stations, or similar research agencies, have been set up at practi-

cally all of the better equipped engineering schools, and research departments provided on an elaborate scale in the larger industries. Research has become a word to conjure with, a cogent catch word in sales talk. It has become the most used word in the literature, and perhaps the most abused word. In this period, graduate study crystallized out from research and assumed a prominent role in most institutions, and graduate degrees have become a further qualification for the young instructor. In view of these facts, we may say that research has been the dominant influence in the third epoch.

The fourth epoch in engineering education, entrance to which seems likely to be hastened by the depression, can be forecast only from facts and trends now either apparent or discoverable, and manifestly, treading in the realm of prediction proceeds with less assurance than along the plotted paths of history. The depression not only marks the beginning of the new epoch, but it yields a clue to its characteristics, because the lashings of the economic storm have revealed certain weaknesses which years of fair weather would not have disclosed. Inasmuch as the most obvious defects in engineering of the past decade are observed to lie in the economic sector and as certain new conditions now growing up which engineering will be required to meet also lie in that same sector, we may appropriately call this new era in engineering education the "Epoch of Economic Adjustment," recognizing, of course, that research and other values previously developed will continue.

That the defects and inadequacies of engineering which have appeared in the severe testing of the past five years are found in its economic commissions and omissions scarcely requires demonstration. Despite the fact that our radios still growl and fade, our automobiles are irresponsive on cold mornings, our concrete floors crack, and a few tragic accidents have occurred, the shortcomings of technical engineering are not fundamental, and by the same token, engineering education, in its technical aspects, has disclosed no radical faults. The areas in which engineering and engineering education have fallen short of their responsibilities are in such matters as unsound valuations for securities, overbuilt industrial plants, lack of diversification in manufactures, railroad improvements contemplating increased traffic that could not materialize, technological unemployment, ill-conceived labor relations, vulnerable centralization of industry, and misjudging of social trends. Not all of these weaknesses have developed within the purview of engineering as now defined, but they represent management wherein engineering techniques might properly be applied. Hence, it seems reasonable to expect engineering education to expand gradually into those areas in order, first to strengthen engi-

neering administration wherein it now includes these matters, and second, to offer preparation for assuming those functions wherein other agencies have been proved incompetent. There lies with engineering the responsibility for the economic control and stability of its own affairs and if that responsibility is not recognized and accepted, engineering education to that extent must be adjudged wanting.

A conspicuous example of the economic maladjustment of engineering curricula is found in their lag behind the specializations resulting from the various technical devices available for home, office, shop, and construction operations, which require a measure of technical knowledge and organization for their distribution and application. Engineering education has become cumbered and choked to a degree by its own output. Large engineering projects no longer represent details designed by a master engineer and his staff; they are rather an assembly of specialties which have been developed by the experts in manufacturing concerns. Training for the technical production as well as for the distribution and application of these devices justifies educational preparation. At the present time colleges of commerce and departments of science vie with engineering schools in this field. Combination courses in engineering and commerce have usually resulted in a mixture of the water of science with the oil of business rather than a homogeneous preparation suitable for the purpose. Since we cannot shorten this giant growth of engineering specialization to fit the procrustean bed of last century's formula of engineering education, we shall have to enlarge the bed.

Many engineers, sensing the need for an adjustment to provide for these miscellaneous technical and administrative specializations, have urged a broadening of engineering preparation by the introduction of various subjects and even of new curricula. To most of us who are directly responsible for administering college curricula, however, this procedure has seemed impracticable, because if such material should be included formally, the course would either have to be extended beyond four years, or else cease to be genuine engineering. Neither can an indefinite number of kinds of engineering curricula be provided to lead to all of these technical specialties. Dean Hoover, in the February issue of the JOURNAL, listed 337 vocations emanating from these specialties to which the title engineer had been appended, and even then the list is not exhaustive, new lines appearing every year. It is significant that the largest engineering school in America has confined its major curricula to the chemical, civil, electrical, and mechanical divisions. These four, with mining and metallurgical engineering and perhaps one or two others added in some places, would seem to suffice at present for

main trunk curricula, leaving the miscellaneous specializations to be treated as branchings rather than as coördinate stems, and to be provided for in post graduate years, even if not as graduate work.

Instead of diluted main curricula, and numerous minor ones, courses in applied science supplementary to engineering curricula, have had a few tryouts with particular objectives in mind, but the possibilities in this direction have not been fully explored. Many educable young men, desiring to enter commercial fields involving engineering specialties, are not much interested in engineering as a creative profession, yet they desire a scientific education of a sort not offered by liberal arts faculties. Institutes of technology, colleges of applied science, and even schools of engineering with a more restricted scope, are the most suitable agencies extant to administer such applied science courses. They need not have the designation of any variety of engineering and might be as noncommittal as A.B. in arts or B.S. in pure science. They would merely constitute a good college education in applied science and would presumably provide a wide range of electives with a view to cultivating a maximum of individual resourcefulness. The innovation would be similar but not quite parallel to the introduction of the elective system in the liberal arts colleges half a century ago, since colleges of engineering would sponsor these supplementary courses much as arts colleges at that time added science to their classical curricula. It is quite within the range of possibility that through the operation of these supplementary applied science courses, certain vocations now considered as trades might ultimately be elevated to the peerage of polite professions, entitled to the trappings of prerequisites and college degrees.

Instead of one pure type of engineer, therefore, we may come to recognize about three varieties of the species: engineer *alpha*, engineer *beta* and engineer *gamma*, to use the customary designations of variations from type. Engineer *alpha* would represent the highly trained technical genius, prepared through graduate study and otherwise to do advanced developmental work; engineer *beta* would be the typical routine designer and administrator commonly produced by the present undergraduate courses; engineer *gamma* might not be an engineer at all in the ingenious inventor sense, although he might be best equipped to do the accessory work that he intends to follow. Occasionally, he might develop into a technical engineer even as arts graduates have done not infrequently. Generally he would perform a liaison function between technical engineering and human wants. Socially and politically all three groups might continue their associations together advantageously, although educationally and legally separate categories might be

recognized. Economics should permeate the training of engineer *gamma* and should flavor more than previously that of all engineers.

Advocating economics content in engineering education does not imply a proposal to extend the time devoted either to classic economics or to branches now within the proper domain of colleges of commerce. Much of the former is too hypothetical to serve the more quantitative requirements of engineers, and secondly, there is no justification for overlapping or encroaching upon those phases of economics that lie within the recognized sphere of colleges of commerce. The applications of economics of which I speak cover those social phenomena and principles of management inherently connected to manufactures, to public service and to the construction industry. For the sake of simplicity, we might, for the purposes of this discussion, invent a new word to denote this field. The word "technonomics," which etymologically would mean the orderly management of technical affairs just as economics means the orderly management of a farm or business, may be used for this purpose. "Technonomics," as applied social science, would employ engineering methodology, viz., thoroughness of analysis, rigorous scrutiny and test of new proposals, strict evaluation of the so called "economic laws" before applying them, conservatism in design and planning, and insistence on economic justification as a condition precedent for most public works. It would recognize corporations as proper agencies of modern economic democracy; it would contemplate a self-governing industry, including the related labor organization; and it would proceed on the assumption of a reasonable employment security for the worker. The time may be not far distant when schools suitably circumstanced will set up "technonomic" experiment stations or institutes of "technonomic" research to test old dogmas and to seek new knowledge that will advance related economic practices comparably with technical achievement.

The depression has disclosed a need for "technonomics" in planning public works that will add to social benefit without stifling private enterprise. "Technonomics" will be needed more and more in scientific bureaus and in regulatory commissions, and all governmental functions—city, county, state, and federal—are becoming increasingly involved in technical operations. For these functions, engineering education must be socially enlightened.

From the depression is emerging a recognition of the potency of technical productivity to restore and maintain economic normalcy. The current press frequently quotes opinions to the effect that television, air conditioning, or some other novelty will prove to be the new development that will overcome the depression. It

will probably be none of these alone, but rather the marketing of numerous new specialties, that will stimulate buying and thus start the wheels of industry. The Brookings Institution, and perhaps others, have pointed out that people have invested disproportionately in securities, thereby encouraging undue plant expansion, and that this situation has produced a lack of balance between fixed capital and liquid funds available for purchase of consumable goods. Why? Because, the market for the ordinary had become saturated, and there were no new attractions to tempt the purse. An economy of plenty, evidently, can be kept in balance as between invested and liquid capital only by devising new conveniences which people will buy in preference to investing with a view to future leisure. If this be true, then the inventive genius of the engineer in creating such goods will play an increasingly important part in our future economic weal, and the significance of this fact should be considered in the engineering education of the future.

The depression has also revealed evidence of a "technonomic" error, viz., that by pointing our educational policies too exclusively toward large scale industry rather than to developing resourcefulness and inculcating an interest in establishing new enterprises on a small scale, we have not only limited the opportunities for our graduates, but we have contributed to economic lopsidedness. Instances might be mentioned of small scale manufactures, founded by engineering graduates, which have weathered the depression more successfully than larger industries. Such enterprises have made the communities affected self-sufficient to an extent, and they give these self-contained areas a stability capable of halting the spread of economic demoralization in times of crisis. The superior industrial stability of France and certain other European countries is attributable, in part at least, to the numerous small industries that tend to localize the economic activities of the towns involved and make them independent of the currents that flow between metropolitan centers. The economic adjustment of engineering education will take into account this prinicple of balanced employment and of diversification, not only with a view to increased opportunities for graduates but also as a factor in the public prosperity.

Perhaps the more perplexing doubt in the minds of some pertains not to what effect the depression may have on the curriculum in the new epoch, but rather to what effect it may have on the future of engineering itself. In the rebuilding of economic systems, will engineering play a larger or a smaller part than in the past? In the acid test of the depression, where social institutions are tried as well as men's souls, to what extent will engineering have been found fundamental and necessary for the rehabilitation?

A few engineers have expressed pessimistic forebodings relative to overcrowding and lack of opportunities in the future. I do not share that view. Instead, my own observations lead me to optimism and confidence. There is no reason to predict a surplus of engineers when there is no diminution in the need for engineering services, the present unemployment to the contrary notwithstanding. Nature's resources, which the engineer diverts for the use of man, are not approaching exhaustion, and man's wants are illimitable, if engineers have but the discernment to discover and the ingenuity to satisfy them. Improving personal conveniences as well as social intercourse and public welfare will make increasing demands on applied science. Also, because of the technical activity in Europe, Latin America, and the Orient, any reasonable hope for regaining foreign markets in world competition has a firmer basis in the fertility of applied science than in the maneuverings of politics. Hence, unemployment of engineers results from underconsumption rather than from overproduction. There can be no surplus of engineering service so long as thousands of accidents occur daily on highways and in industry; so long as conflagrations destroy many lives and millions in property; so long as floods run rampant over town and country side; so long as noise and dirt in cities impair physical and mental health; so long as electric lights are but 5 per cent efficient and the illumination supplied is but a fraction of the need; so long as power transmission is limited to a short radius; so long as public service rates require regulation; so long as cities are ugly and inconvenient; so long as enormous waste exists in coal, oil and gas production; so long as most of the energy of fuel is lost in the conversion; so long, *in fine,* as man's personal and social welfare can be further promoted by exploitation of nature's riches. Superior skill in performing these services only is needed to yield an expanding demand for engineers.

This judgment is supported by a statistical study of professional growth. When graphs are drawn for other professions showing the number of practitioners in the United States per million population at the successive censuses, such graphs show a fairly constant ratio through the years. For engineering, on the contrary, the graph rises at a steep slope showing a marked and fairly constant increase in the ratio of engineers to population. Thus in 1880 there were 200 per million inhabitants, in 1890, 600; in 1900, 700; in 1910, 1000; in 1920, 1250; and in 1930, 1750. The notable increase results, of course, from the great expansion of the profession in various branches and from the growth in scientific knowledge. Graphs showing social trends do not make sharp angles, hence, we might expect this graph to continue its upward direction, even if at a diminished slope.

A second analysis further supports the conclusion. By determining from standard life tables the total mortality in each of the various professions, the number of annual replacements caused by death was ascertained. The average annual increase over the past twenty years was taken as an index of new positions resulting from growth in services by the profession. The sum of these two figures indicates the total number of openings in each profession per year under normal business conditions. This figure was then divided by the number of annual entrants to obtain the ratio of the probable number of positions to the number of entrants. These ratios were as follows: medicine, 1.00; dentistry, 1.78; architecture, 1.17; law, 0.70, and engineering 1.68. In medicine, dentistry and law, these figures are consonant with other data collected by men in those fields. If this procedure is valid, we should conclude that with the field enlarged as suggested in the foregoing paragraphs, we may expect a 68 per cent increase in the annual demand for engineers in the first years of normal operations.

The phenomenal growth in engineering in the past is not surprising in the light of the achievements in promoting individual convenience and public weal. By means of engineering, men ride swiftly on land, on water or in the air; the nation is bound together by strands of wire, bands of steel and ribbons of concrete that reduce social intercourse to that of a neighborhood; one lifts his telephone and the civilized world awaits his call; pictures are flashed to newspapers; by engineering, the President of the United States chats intimately with us at our family fireside about affairs of state, the leaders of the world proclaim their messages of comity to all nations, and choice programs of artists are carried to our homes; by engineering, burdens are shifted from flesh to steel, mechanical servants attend us, eliminating child labor and allowing leisure for education and enjoyment; by engineering, lustrous fabrics come from the loom without the slow travail of the silk worm; by engineering, cities are made healthful, foods improved and standards of living advanced. Will that current of progress slacken or diminish when there is no exhaustion of nature's resources, when the needs of men are unlimited in variety, and when the usable scientific knowledge is ever increasing?

I think not. After these years of disorder have passed, when normal procedures shall have been restored whereby industrious men may freely exchange their labor for necessities and comforts, when skill, thrift and diligence again shall be accounted as virtues, and when investments can be made with confidence in the integrity of political institutions, the march will be resumed. Every year, a million educable young men arrive at the age of vocational choice with the regularity of the lines of a marching army, and

that eager approach of aspiring young men will neither cease nor lessen. They comprise a crop that can neither be plowed under nor limited by subsidy. At present, over 20,000 annually seek entrance to colleges of engineering and that number is growing. What engineering will become will not be determined by the needs and openings that we of this generation see in the industry ahead; it will be limited only by the abilities and purposes of that never ceasing stream of young men approaching our doors. Industry of today will not shape their destiny; on the contrary, they will fashion industry of tomorrow. To ascertain and to cultivate their individual potentialities is the prime problem of engineering education. Moreover, when an ambitious youth with a God-given ability and aspiration to be an engineer seeks admission to the profession, there is no group nor guild of men that has the moral right to deny him entrance, merely because the profession seems crowded and competition is already keen. He has a right to his chance as well as any man already in practice. Merit alone must determine who will be engineers. Even if all who graduate do not find places in traditional engineering, my faith in the virtues of engineering education, with its ideals of thoroughness, efficiency, service, and honesty, lead me to believe that it is unsurpassed as preparation for living in this 20th century civilization, and that, in view of the many public issues of a technological character, we are in no danger of social impairment from having too many citizens with an engineering education.

Furthermore, various studies have shown that engineering is the field that attracts many of the ablest and most virile of oncoming youth. They recognize that in science and invention lie those unexplored domains wherein discovery, giving right of possession, promises rewards for the discoverer and benefit to mankind. There are the modern frontiers and the eldoradoes that challenge the spirit of the adventurer. With physical frontiers gone, the new resources of the nation are mental rather than metal, to be dug from minds rather than from mines. Hence, engineering education must be adjusted to the new economy in order not only that individual young men may find college offerings suited to their aptitudes and inclinations, but also that society itself may keep on an even keel in the varying currents of a scientific age.

That this view is not wholly the result of a natural bias of thought on my part is indicated by the following quotation from a recent book in the field of political science, "Government and Technology," by William Beard. "The functions of industrial society and government are so largely technological in character that the engineer will, whatever his personal views, occupy a central position in the future; his science will become more and more indispensable

to the conduct of government and to the stability of society. . . . (But) the challenge of the new age to engineers is still open and will long remain open. It is to be hoped that the rising generation of engineers will face that challenge boldly and aptly apply the indispensable instruments of their science—rationality and efficiency—to both government and industry."

In conclusion, the economic adjustment of engineering education pertains not only to personal careers but also to the social placement of the profession. The bulk of undergraduate education will continue without radical change, because it accords with a certain range in the natural aptitudes and interests of youth and because it is sufficiently flexible to meet changes within its scope. That scope needs to be enlarged, however, to include a surrounding zone of vocations where a maximum of adaptability will be required. If I were to mention a physical structure symbolic of engineering education in the new epoch, it would be a building somewhat like the Empire State Building in form. The main body of the building would represent the substantial bulk of our present curricula and procedures, serving well an existing and continuing need. Rising above this would be a tower of smaller plan representing graduate study for highly technical engineering. The feature most suggestive of the proposed economic adjustment would be the divers approaches and services linking the building to the world of business and living. If these last be made adequate, every room and floor of the building will be utilized advantageously.

It seems to me that the new epoch in engineering education is opening with a rosy tint at the horizon, for amidst the general devaluations of the present period, technical engineering stands at par, and the new era promises yet greater opportunities through expansion into adjacent areas where the depression has shown the need of engineering methodology. The "finale" of Professor Scott's fine report on the great work by the Board contains the statement, "And now we come to the close of another chapter." I am not sure whether that sentence stands at the close or at the opening of a chapter. It may be at the close of a chapter but at the opening of an epoch. It reminds me of an incident that occurred near the end of the great constitutional convention in 1787. The venerable Franklin arose after the final adoption, and referring to the figure of a half sun with darting rays that decorated the back of the Speaker's chair, said: "As I have sat here following the deliberations of this convention, my gaze has frequently fallen upon the figure on the back of the Speaker's chair. At times, I have been uncertain whether it represented a rising or a setting sun. Now, Sir, I am convinced that it represents a rising sun, and

that the sun of this nation, under this new constitution, is rising to a more glorious day."

In a similar way, I believe that the sun of our profession is in the ascendant, and that in the new epoch, with a restoration and strengthening of economic agencies, engineering education, adjusted in its scope and objectives to meet the new conditions, will attain higher levels and will prepare even greater numbers of ambitious young men to attain the goals of their choice and to enjoy the high privilege of effective citizenship in a scientific civilization.

ADDRESSES OF WELCOME

By HONORABLE EUGENE TALMADGE

Governor, State of Georgia

Mr. President, Dr. Brittain, Members of the Society for the Promotion of Engineering Education, and Distinguished Guests: It is useless for me to say that I am delighted to be here with you this afternoon.

I should like to tell you what my wife said to me about three weeks ago. One night we had some guests and she said, "Gene is trying to tend to my farm, and he is trying to tend to the federal business, and he is trying to tend to the State of Georgia, and I think he is overcropped."

I did take time off to have a wonderful fishing trip. I left here Sunday morning and went down through Telfair County and down below Tallahassee, and I want to tell you a real fish story. Yesterday we caught between 900 and 1000 pounds of fish and we caught them in an hour and a half. That was in the Gulf just below Tallahassee. Most of the party went out deep sea fishing in the ocean. A few of us thought that we might get a little sea sick, that probably we were not in the best of condition for salt water, and that we would stay on the banks of the river. We did not have so much luck on the river and I think having the Commissioner of Game and Fish with us was the cause of it. He was dressed up in a green sweater and red checkered knee trousers, and he had about $250 worth of fishing tackle and I think he scared most of them away.

I caught the train last night from Thomas back to Atlanta, and my secretary notified me that I was to come out here and speak to the Society of Engineers of the whole country, and I told her to get busy and write me a speech, and I am going to tell you what she wrote. Let me see how it starts off.

"Engineering, broadly speaking, is the science by which matter is made useful to man. The term originated in connection with the running of engines and formerly referred only to the profession now known as mechanical engineers.

"The first engineering feats were rather of structural and military character as witnessed by the Pyramids and the ruins of bridges, roadway and military camps.

"With the advance of science and invention the field of engineering became so large that it was divided into numerous departments, each of which is considered a separate profession.

"Among these are civil engineering which includes construction and maintenance of such public works as roads, bridges, etc.

"Mining engineering, the location and securing of ores; electrical engineering dealing with the construction and utilization of electric power; hydraulic engineering, the use of waterpower and mechanical engineering dealing with construction and operation of machinery. Other branches whose names imply what work is included are chemical, gas, irrigation, army, agricultural, sanitary and marine engineering."

Then my secretary jumped way back to the Appian Way.

"Appian Way, the most famous road begun in 300 B.C. by the Censor Appius Claudius Caecus." (I always thought Caesar started it.) "It was 350 miles long and from 14 to 18 feet wide, with paths for foot passengers extending on each side. Constructed at great expense and so well built that parts of the road still remain. Troops made swift marches along this road in the martial days of Rome and it was the greatest highway between Rome and the East. For a long distance from Rome the road was lined by tombs and monuments of the rich and famous."

Well, my secretary didn't have a fair chance today or she would have had you a whole lot more.

You know, before I get away from the subject of secretaries, when there is almost every kind of strike in this country, there is one kind of strike I might sympathize with and that is a secretaries' strike for the speaker not telling the name of the person who wrote his speech for him. I think that we ought to have some of that.

But this engineering question, especially since we have the greatest engineering school in the South right here in Atlanta run principally by appropriations from the textile industry of Georgia. I have seen this school grow from its infancy and turn out a great student body every year. They have added to the material wealth not only of Georgia but of the South and the whole Union.

About a week ago they had a meeting of agricultural engineers over at Athens, and knowing that I was a farmer governor of Georgia, some of those agricultural engineers came by and wanted me to go over and meet with them. I was very sorry I could not go.

Of course, converting matter useful for man is the background of engineering. Agricultural engineering is one of the principal branches of engineering, but right at this time it is pretty hard to realize the importance of trying to produce more agriculturally when we have a government telling us to produce less. Somehow

it just doesn't fit. My idea of prosperity for the country is to have an abundance, to produce what you need here in America, to make the ability of the engineers of your country worth something to your country, and not curtail on what you are making here and import it from abroad. I did not intend to stumble on that. That was just an accident, but I have been in that groove so long I just could not get away from it.

I want to tell you all about a trip I took up to Lookout Mountain about four years ago. I went up to the top of Lookout Mountain with a graduate of Georgia Tech who lives in Chattanooga, an engineer and a good one. We drove around that mountain, and he looked at me and he said, "Talmadge, do you know this road doesn't miss by twenty feet the Indian trail that went to the top of Lookout Mountain?" I said, "No, I didn't know that." He said, "Well, it is a fact. They had some engineers back in those days."

I talked with my brother who used to live in Lima, Peru. He told me about those wonderful terraced gardens in that country, about the road from the sea up to the top of the mountain, where now it is a beautiful paved highway, and yet it follows the paths that the Indians took a thousand years ago in their race to bring fish fresh from the sea.

Engineering, the most practical study that we have that can benefit humanity more than the study of anything else, is broadening out in this modern day. I am proud that Georgia is able to contribute to further such a great and wonderful purpose. I am proud that we have the honor to welcome you men here, who deal in the fundamentals, how to handle the elements, how to deal with the rocks and the earth, the chemicals and other things that a great and wise Providence has placed here to make life's road easier for us to travel.

I hope that your stay in Atlanta will be pleasant. I hope that you will see what wonderful engineering we have around Atlanta, and after you see some of these beautiful homes on Paces Ferry Road that compare favorably with any of the homes on the Hudson River, then you can go out to Stone Mountain and do not look too close at the scratches that have been made on the side of that rock because the real Georgians feel sort of like some engineers have fallen down there, but look at the rock as one of the wonders of the world, a great rock rising out of that plain section.

Keep on with your work. There are thousands and thousands of things yet that engineers have got to find. They have got to branch out and teach us how to enjoy the wonderful things around us.

By M. L. BRITTAIN

President, Georgia School of Technology

Mr. President, Ladies and Gentlemen: I count it an honor as well as a privilege to welcome here the representatives of this great organization, the Society for the Promotion of Engineering Education.

It is the first time, I understood the President to say, that you have been to the far South, to the deep South, and I believe they call it sometimes, that part of the country below the Smith and Wesson Line. I do not know what you expected to find here, but if you like us as well as we like you, I am sure everything will be all right.

We wanted you here. I want you to know and to understand that it is not an accident that you hold this meeting here this afternoon. We sent Professor McDaniel and others of our faculty to bring you to this institution, and so it is on purpose that we have you. A Georgia girl in the mountains went before a preacher to be married, and he asked the usual questions. First, in mountain fashion, he asked the man, "Will you have this woman to be your wife?" to which he answered very promptly, "Yes." Then it came time for the other side and he said to the young woman, "And will you have this man to be your husband?" she shifted her chewing gum from one side of her mouth to the other and said, "I come a purpose to do that very thing." And so it is just that way with us. We have you here on purpose.

We hope you like Georgia Tech. This is your home for some days. I perhaps ought to tell you a word or two about it. It is one of the youngest of our state institutions. It was born in 1888 and opened its doors in October of that year, but despite that fact it has been popular and it has had the largest increase in student body of any college in the state. We have 1853 on our rolls this year, all men, and to show you how cosmopolitan we are, this student body of ours represents thirty-eight states and twelve foreign countries.

Our faculty is much the same way, rather different from the average Georgia or southern faculty. Dr. Boggs, whom I see here, and I and one or two more of the Heads are from Georgia. Dr. Crenshaw is from Virginia, Dr. McDaniel is from South Carolina, and several others are from the South, but an equal number of the heads of our departments come from the North. Two of them come from Massachusetts. One, the head of our Aeronautical Department, comes from Massachusetts Tech, the head of our Architectural Department from Harvard, and then we have from New

York, Illinois, Indiana, and several other northern states, heads of departments and members of our faculty. I am glad of this and have always thought it meant well for the school to be sure that we had nothing like inbreeding.

Now another thing I want to ask of you. While you are here see something of this city of ours. We are not going to hold you—or at least I hope you will not let these wise-looking leaders hold you here—all the time. So I hope you see something of this proud city, a city that captures the eye of everyone who comes to it. Since Sherman came through rather carelessly with fire, as Henry Grady said, we have built a handsome city that has attracted attention throughout the world.

I want you to see that cyclorama in Grant Park. Make those professors on the Entertainment Committee show you that picture of the Battle of Atlanta; and then too that unfinished Mountain memorial. A cousin of mine in England said it is talked about more than any other work in the South in spite of the fact that it is not completed. It is a memorial to the Confederacy standing out on Stone Mountain.

I hope some of you will like us well enough to want to come back again and perchance to live with us. We have found that you people from the North, East and West amalgamate easily with us in Atlanta and prove to be among our foremost citizens. We have room for you here too. Don't let anybody tell you differently. The Editor of the *Macon Telegraph*, Mr. W. D. Anderson, is quite a forceful power in this state and tells a tale of a fishing party of which he was a member, in the southern part of Georgia, on the Satillo River. It was just before they brought a number of Belgians over here to settle down in southern Georgia. There were a dozen white men in the party, and an old Negro cook listened with a great deal of anxiety to the talk that was going on about those Belgians who were soon to come. After awhile he went up to Mr. Anderson and said, "Marse William, is it true what I hear you white folks talk about, that you are going to bring a whole lot more white folks down here to Georgia from that foreign country?"

Mr. Anderson said, "Yes, that is true. We think they will make good citizens."

"Well," said the old darky, "Marse William, please don't do that. Us Negroes has about all the white folks we can support now without bringing any more."

We look forward to the results of your deliberations with interest. We know they will be of value to us and to engineering schools all over this land. We are all engaged in the effort to show these young men who come to our schools how to prepare themselves as well as possible for life.

Do you know I heard something fine a week or two ago at our commencement services when a preacher, who is one of the most brilliant men in this city, said among other things to the graduating class of 300: "I respect you young men. Do you know I have never in my life met an engineer who was anything of a Communist; who had anything of a Red tendency, and I have come to believe that the world looks to you more for its real upbuilding and constructive work than to any of the other college graduates."

Wasn't that fine? I do not believe that you ever heard that before. It was new to me. It is splendid and I think it is true. It is true in my own experience just as it was true with Dr. Louie Newton's. As I said, we are doing our best to show these young men how to do what they can to make their lives successful. I hope we do think about what we ourselves tried to do and what successes and ambitions we had when we were their ages.

"Across the fields of yesterday he sometimes comes to me,
A little lad just in from play—the boy I used to be.
And then he smiles so wistfully once he has crept within,
I wonder if he hopes to find the man I might have been."

So I trust each one of us has something of that feeling in our hearts as we meet the youth of the land each September.

Let me again express our pleasure which I do—on behalf of our own faculty, on behalf of Clemson, and Alabama, and North Carolina, and all the colleges of the southeastern section of our United States. I say again that our hearts and hands are open to you and we are glad to see you here with us.

MINUTES OF COUNCIL MEETINGS HELD AT THE GEORGIA SCHOOL OF TECHNOLOGY MEETING, JUNE 24–27, 1935

Present: C. C. Williams, H. P. Hammond, G. C. Shaad, F. L. Bishop, W. E. Wickenden, R. I. Rees, A. M. Greene, Morland King, P. T. Norton, Harry Rubey, F. Ellis Johnson, A. P. Poorman, G. P. Boomsliter, H. B. Dirks, C. H. Willis, C. W. Park, D. C. Jackson, A. N. Talbot, C. F. Scott, H. B. Walker, B. R. Van Leer, F. E. Ayer, J. B. Finnegan, G. W. Case, C. E. Davies, O. M. Leland, W. M. Cobleigh, R. A. Seaton, C. L. Eckel.

The report of the Secretary was presented and ordered printed in the JOURNAL.

The report of the Treasurer was read and ordered printed in the JOURNAL.

Invitations to hold the 1936 meeting were received from Massachusetts Institute of Technology and Harvard University, University of Texas, University of Wisconsin, University of Minnesota, and eight engineering schools in New York City. Council voted to hold the forty-fourth annual meeting at the University of Wisconsin.

Motion made that the Committee on Relations with other Engineering Societies consider the matter of adjusting the time of meeting so as to conflict as little as possible with other meetings.

Dean Van Leer invited the Society to meet at the University of Florida in December or January if semi-annual meetings are held.

The New York institutions renewed their invitation for the Society to meet there in 1937.

The following amendments to the Constitution and to the By-Laws of the Society were approved, and later adopted by the Society. (See minutes of the annual meeting.)

The certificate of membership was approved with slight modifications to be made by the Executive Committee.

The matter of indexing the publications of the Society was referred to the Executive Committee with approval in principle and authority to expend a sum not to exceed $1,000.00 provided other cost and services may be obtained from outside sources.

The petition of a group for the establishment of a Division of Electrical Engineers was approved.

Council expressed its sympathetic interest in Mathematics and encouraged the group to take necessary steps looking forward to the formation of a division at a later date.

Time on the 1936 program was asked for adequate discussion of members of engineering faculties in outside engineering practice. Sanitary and hydraulic. Committee to investigate the matter of outside practice of teachers of Engineering.

Council authorized the Division of Drawing to have a conference at the University of Michigan under the auspices of the Division and the University but without the expenditure of any funds of the Society.

Council adopted the pin as presented, cut of which appeared in the April JOURNAL. Watch charms are also to be made available to the members.

Dean Seaton reported that no funds were available for summer schools.

Dean Leland reported for the Committee on Engineering Degrees. Motion made that the report of the committee be submitted to the Society without favorable or adverse recommendations from the Council.

Chairman Hammond reported for the E. C. P. D. Committee on Accrediting Engineering Colleges as follows:

At the last Annual Meeting of the Society for the Promotion of Engineering Education a report on the work of the Engineers' Council for Professional Development in the matter of accrediting engineering colleges was presented in which it was stated that complete plans for the accrediting program had been made by E. C. P. D.'s Committee on Engineering Schools, and that these proposals were before the seven constituent societies of E. C. P. D. for approval. The Society for the Promotion of Engineering Education gave its approval, constituting E. C. P. D. as its agency in the matter of accrediting, at the Ithaca Meeting, June, 1934. Other societies also gave their formal approval, the last such approval having been given in January, 1935. The program approved by these actions is covered in full in the last Annual Report of E. C. P. D., a copy of which is appended to this report as a matter of record.

Upon receipt of the last of these approvals the Committee on Engineering Schools submitted lists of nominees for the so-called Delegatory Committees which will be responsible, in part, for carrying out the accrediting program. Delegates representing the constituent societies have now been appointed to these committees in Regions 1 and 2 (New England and the Middle Atlantic States), the last such appointments having been made on May 20, 1935. The Committee on Engineering Schools was not able to undertake the program of accrediting actively until that date, although it was otherwise fully prepared to do so. As soon as the last approval of delegates to the committees was received, steps

were taken to notify engineering colleges in Regions 1 and 2, in which regions the actual work of accrediting will be begun.

It is anticipated that the active work of carrying out the program will be in progress and that it will be carried out promptly in the Fall of 1935.

As soon as experience in New England and the Middle Atlantic States has accumulated sufficiently to warrant extension of the program, the Committee will request authority to extend its program to other sections of the country, and it is hoped that accrediting will be under way through the entire country during the year 1936, with the tentative goal of completing the program substantially by October, 1937.

Respectfully submitted,

H. P. HAMMOND,
Representative of S. P. E. E. on E. C. P. D. Committee on Engineering Schools.

Note: Since the above report was presented a considerable number of engineering colleges in New England and the Middle Atlantic States have submitted requests for consideration in the matter of accrediting to the Engineer's Council for Professional Development.

Chairman Scott reported for the Progress Committee as follows:

1. That the annual report of progress in the field of engineering education cover the academic year ending July 1 (but not necessarily excluding data available in the fall, such as enrollments).
2. That the committee present its report in the following December.
3. That the Committee of five be a continuing committee with normally one or more new members each year; changes in membership being made January 1st.

Management. Special committee of five to report different branches of engineering to be represented.

Twenty-five new members were elected.

Fenn College and Wayne University: Motion that both of these institutions' applications be deferred and no action taken pending the appraisal of E. C. P. D. Committee on Accrediting Engineering Colleges.

Motion that dues for 1935–36 be discounted 10 per cent if paid on or before January 15, 1936.

The budget for 1935–36 was adopted.

Council authorized the Secretary's office to secure the enrollment in engineering colleges each year.

The question of admission of graduates of engineering schools to law schools is to be presented to the Committee on Studies of the American Council on Education.

W. E. Wickenden was elected a representative of this Society to the American Council on Education.

The report of the Committee on Relations with Industrial and Trade Associations was received and filed.

Council approved the formation of the Allegheny Section of the Society.

Council appointed a Committee on Resolutions which presented the following:

The Council of the Society for the Promotion of Engineering Education has been greatly saddened to learn of the death of William T. Magruder. As Secretary and President of the Society, he was influential in shaping its policies during a formative period, and his vision, enthusiasm and tireless activity have contributed much to its growth and expanding usefulness. Not the least of his contributions has been the inspiration of his rare personality. A keen critic, alert and vigorous in debate, he was also a thorough scientist and a sympathetic and helpful friend.

In adopting this tribute to his memory, the Council wishes at the same time to convey to the stricken family assurances of heartfelt sympathy in their bereavement.

Signed,

FRED E. AYER,
C. W. PARK,
Committee.

June 25, 1935

Council presented the retiring president, C. C. Williams, with the first Society pin.

MINUTES OF THE FORTY-THIRD ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, GEORGIA SCHOOL OF TECHNOLOGY ATLANTA, GA., JUNE 24–27, 1935

The forty-third annual meeting of the Society for the Promotion of Engineering Education was held at the Georgia School of Technology, Atlanta, Ga., June 24–27, 1935. The meetings were held in the Armory. The theme of the meeting was "Looking Ahead." 110 institutions had official representatives present and 687 members and guests registered.

On Saturday, June 22, the Society held a joint conference with the A. S. M. E. at Norris Dam, Tenn. This meeting was arranged by the Knoxville Section of the A. S. M. E. and was enjoyed by those who attended.

There were fifteen conferences held in connection with the meeting—Chemical Engineering, Civil Engineering, Coöperative Courses, Drawing, Electrical Engineering, Engineering Economy, English, Industrial Engineering, Junior Colleges, Machine Design, Manufacturing Processes, Mathematics, Mechanical Engineering, Mechanics and Physics. The Southeastern Section of the Society also held a meeting at eleven Monday morning. These conferences were held on Monday and Tuesday mornings and evenings; luncheon and dinner meetings were also held by the groups.

At noon on Monday the Council was entertained by the Georgia School of Technology at a typical Georgian dinner.

The ladies were entertained on Tuesday morning with an excursion to Druid Hills and Emory University with luncheon at the Druid Hills Country Club. In the afternoon there was a trip to Stone Mountain. On Wednesday there was an excursion to Peachtree Hills with luncheon at the Brookhaven Country Club, and tea at the home of Mrs. T. W. Fitzgerald.

Monday, June 24, 1935

The opening session was called to order at 2:00 P.M. by the President of the Society, C. C. Williams, Dean, College of Engineering, State University of Iowa. M. L. Brittain, President, Georgia School of Technology, welcomed the Society to the South. The Secretary of the Society, F. L. Bishop, presented his report for the year. He also read the report of the Treasurer, W. O. Wiley, who was unable to be present. Vice-President H. P. Hammond took the chair while the President delivered his presidential

address, "The New Epoch in Engineering Education." D. C. Jackson, Massachusetts Institute of Technology, presented a paper on the "Objectives of Engineering Education." W. E. Hotchkiss, Armour Institute of Technology, spoke on the "New Economics for Engineers." These papers were discussed by C. J. Freund, University of Detroit, H. S. Rogers, Brooklyn Polytechnic Institute, and G. W. Barnwell, Stevens Institute of Technology.

At eight o'clock there was a social get-together on the lawn in front of the dining hall. At this time the Big Bethel Choir presented "Heaven Bound," which was much enjoyed by all present.

Tuesday, June 25, 1935

The second session was opened at 2:00 P.M. by President Williams. This session was devoted to "Undergraduate Engineering Education in the Future." Under this heading, R. E. Doherty, Yale University, presented "The Curriculum—Effects of Changing Conditions—Content"; R. G. Tyler, University of Washington, "Some of the Social Implications of Engineering Education"; Douglas S. Anderson, Tulane University, "The Student"; and H. M. McCully, Carnegie Institute of Technology, "Reappraisal of Drawing in the Curriculum." These papers were discussed by M. S. Coover, University of Colorado, R. L. Sweigert, Georgia School of Technology, T. H. Morgan, Worcester Polytechnic Institute, and E. F. Chandler, University of North Dakota.

Wednesday, June 26, 1935

The third session was opened by President Williams at 9:30 A.M. and was devoted to "Graduate Work." After reading the report of the Committee on Graduate Work, Vice President H. P. Hammond, Chairman of the Committee, took the chair. Prepared discussions were read by Walton C. John, U. S. Office of Education, on "Enrollments and Degrees"; C. E. Tucker, Massachusetts Institute of Technology, on "Examination Methods"; J. W. Barker, Columbia University, on "Graduate Work and the Faculty"; W. E. Wickenden, Case School of Applied Science, "Relationship of Graduate Work to Undergraduate Work"; Geo. B. Thomas, Bell Telephone Laboratories, "Industry and the Graduate of Advanced Courses." Discussed by Thorndike Saville, New York University, C. J. Freund, University of Detroit, and D. C. Jackson, Massachusetts Institute of Technology.

The fourth session was called to order at 2:00 P.M. and the topic under discussion was "Research an Instrumentality in Engineering Education." G. C. Blalock of Purdue University read the report of the Committee on Engineering Research. F. W. Marquis, Ohio State University, discussed this subject under Me-

chanical Engineering; S. C. Hollister, Cornell University, under Civil Engineering (read by S. B. Lilly, Swarthmore College); E. E. Randolph, North Carolina State College, Chemical Engineering. These papers were discussed by W. H. Vaughan, Georgia School of Technology, G. C. Blalock, Purdue University, A. B. Domonoske, Stanford University, H. S. Rogers, Brooklyn Polytechnic Institute, F. E. Giesecke, University of Texas, M. L. Enger and A. N. Talbot, University of Illinois.

The annual dinner was held on the lawn and the Society was honored by having as its first speaker the Governor of the State of Georgia, Hon. Eugene Talmadge. The Nominating Committee presented the following report and upon motion the Secretary cast the unanimous ballot of the Society for the officers and the members of Council:

For President: Douglas S. Anderson, Tulane University, New Orleans, La.

For Vice-Presidents: P. H. Daggett, Rutgers University; S. B. Earle, Clemson College.

For Secretary: F. L. Bishop, University of Pittsburgh.

For Treasurer: W. O. Wiley, John Wiley & Sons, Inc.

For elective members of Council for three years: J. W. Barker, Columbia University, M. M. Boring, General Electric Co., A. B. Domonoske, Stanford University, L. E. Grinter, A. & M. College of Texas, T. H. Morgan, Worcester Polytechnic Institute, S. C. Ogburn, Bucknell University, F. L. Plummer, Case School of Applied Science.

In accepting the presidency of the Society for 1935–36, President Anderson said: "I feel that this is the greatest honor that could have come to me as an engineering educator. I am not certain just what are my qualifications for this high position other than the fact that I am one of the veterans of the Society, celebrating this year my 35th anniversary as a member. And, while I am deeply grateful for this great honor to me personally, my gratification is in no way lessened by the realization that I am the instrument for the expression of the recognition on your part of the work that is being done in our beloved Southland for engineering education.

"You know, of course, as well as I do, that the progress of engineering education in the South has not covered the distances that it has in the East, in the West, and in the North, but I think the rate of acceleration, speaking in engineering terms, has been quite high particularly in recent years and, therefore, I must repeat that this honor to me is a recognition on your part of what we are trying to do in the South and that in the usual effective way in

which engineers work you have gone just about as far south as you possibly could to find a man for this high position.

"I thank you most sincerely for this expression of your confidence in me and I shall endeavor in every way to uphold the high ideals and the fine traditions of the Society for the Promotion of Engineering Education."

The Chairman of the Lamme Award Committee, O. W. Eshbach, American Tel. & Tel. Co., presented the report of that committee which recommended that the eighth Lamme medal be awarded to William Elgin Wickenden, President of Case School of Applied Science. President Williams presented the gold medal to Dr. Wickenden who accepted it with appreciation of the honor bestowed upon him.

Addresses were delivered by President M. L. Brittain, Georgia School of Technology and by President Raymond Walters, University of Cincinnati.

THURSDAY, JUNE 27, 1935

The fifth session opened at 9:30 with President Williams in the chair. Amendments to the Constitution and to the By-Laws which had been submitted to the Society were approved. These amendments are:

Constitution, Article II. Institutional members shall be educational institutions giving instruction in engineering and shall be of two classes, active and associate. The active institutional members shall be recognized institutions giving baccalaureate or equivalent degrees for curriculums in engineering. Associate institutional members shall be other educational institutions giving instruction in engineering. Institutional members shall be entitled to representation at all meetings of the Society or its divisions by regularly appointed delegates, one for each institutional member concerned. By-Laws, Second: The President, two Vice-Presidents, Secretary and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to expenditures of money of the Society, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

The meeting was then turned over to Vice-President G. C. Shaad. The subject of the meeting was Professional Status and Employment of Graduates. "Methods Used by Engineering Colleges for Aiding Graduates in Securing Employment" was presented by R. M. Barnes, University of Iowa; "Employment Methods Used at Purdue University and Instruction for Young Graduates Seeking Employment," prepared by J. E. Walters, was read by F. W. Slantz, Lafayette College; "Employment of Engi-

neering Graduates in Comparison with Graduates from Arts Colleges and Schools of Business" was presented by M. M. Boring, General Electric Company; "The Employment Status of the Engineer," by F. M. Feiker, American Engineering Council; "Activities of E. C. P. D. as They Affect Employment," by R. I. Rees, American Tel. & Tel. Co.; and "Employment in Small Industries," by C. H. Casberg, University of Illinois. J. R. Bangs, Cornell University, and R. C. Disque, Drexel Institute, led the discussion.

The sixth session was called to order by Vice-President Hammond at 2:00 P.M. C. E. Davies, American Society of Mechanical Engineers, presented a paper on the "Voice of the Profession in Engineering Education," and P. H. Daggett, Rutgers University, on Licensing Boards.

The following reports were presented: Relation with Engineering Societies, by R. I. Rees, Chairman; Comprehensive Examinations, by J. W. Barker, Chairman; and Titles of Engineering Degrees, by O. M. Leland, Chairman.

There is appended herewith the program of the general meetings and of the conferences.

The meeting adjourned at four o'clock to meet at the University of Wisconsin in June, 1936.

PROGRAM OF 43RD ANNUAL MEETING

JUNE 24–27, 1935

JOINT MEETING OF A. S. M. E. AND S. P. E. E.,
NORRIS DAM, TENN., JUNE 22, 1935

GENERAL SESSIONS

Monday

P.M.

2:00 **Looking Ahead:**

Address of Welcome, M. L. Brittain, President, Georgia School of Technology.

Presidential Address: The New Epoch in Engineering Education. C. C. Williams, Dean, College of Engineering, State University of Iowa.

Objectives in Engineering Education. D. C. Jackson, Massachusetts Institute of Technology.

The New Economics for Engineers. W. E. Hotchkiss, President, Armour Institute of Technology.

Tuesday

P.M.

2:00 **Undergraduate Engineering Education in the Future:**

The Curriculum,—Effects of Changing Conditions—Content. R. E. Doherty, Yale University, reporting for Committee on Length and Objects of Engineering Curricula.

Some of the Social Implications of an Engineering Education. R. G. Tyler, University of Washington.

The Student. D. S. Anderson, Tulane University, reporting for Committee on Orientation of Students.

Reappraisal of Drawing in the Curriculum. H. M. McCully, Carnegie Institute of Technology, Chairman, Division on Drawing.

Wednesday

A.M.

9:30 **Graduate Study:**

Report of Committee on Graduate Study. H. P. Hammond, Chairman.

Discussion:

Enrollments and Degrees. W. C. John, U. S. Office of Education.

Examination Methods. C. E. Tucker, Massachusetts Institute of Technology.

Graduate Work and the Faculty. J. W. Barker, Columbia University.

Relationship of Graduate Work to Undergraduate Work. W. E. Wickenden, Case School of Applied Science.

Industry and the Graduate of Advanced Courses. Geo. B. Thomas, Bell Telephone Laboratories.

P.M.

2:00 **Research an Instrumentality in Engineering Education:**

Report of Committee on Engineering Research. C. F. Harding, Purdue University, *Chairman.*

Electrical Engineering. C. F. Harding, Purdue University.

Mechanical Engineering. F. W. Marquis, Ohio State University.

Civil Engineering. S. C. Hollister, Cornell University.

Chemical Engineering. E. E. Randolph, North Carolina State College.

6:30 Election of officers.

Presentation of Lamme Medal.

Address: Hon. Eugene Talmadge, Governor, State of Georgia.

Address: Raymond Walters, President, University of Cincinnati.

Thursday

A.M.

9:30 **Professional Status and Employment of Graduates:**

Methods Used by Engineering Colleges for Aiding Graduates in Securing Employment. R. M. Barnes, University of Iowa.

Employment Methods Used at Purdue University and Instruction for Young Graduates Seeking Employment. J. E. Walters.

Employment of Engineering Graduates in Comparison with Graduates from Arts Colleges and Schools of Business. M. M. Boring, General Electric Company.

The Employment Status of the Engineer. F. M. Feiker, American Engineering Council.

Activities of E.C.P.D. as They Affect Employment. R. I. Rees, American Telephone and Telegraph Company.

Technical Employment and Training. H. L. Davis, New York Telephone Company.

Employment in Small Industries. Carl H. Casberg, University of Illinois.

P.M.

2:00 **Voice of the Profession in Engineering Education:**

For Societies. C. E. Davies, American Society of Mechanical Engineers.

For Licensing Boards. P. H. Daggett, Rutgers University.

Committee Reports:

Relations with Engineering Societies. R. I. Rees, American Telephone and Telegraph Company, *Chairman.*

Comprehensive Examinations. J. W. Barker, Columbia University, *Chairman.*

Titles of Engineering Degrees. O. M. Leland, University of Minnesota, *Chairman.*

Adjournment.

PROGRAM OF CONFERENCES

CHEMICAL ENGINEERING

F. C. VILBRANDT, Iowa State College, *Chairman*

Monday

9:30 A.M. Report of Study on Chemical Engineering Laboratory Instruction in the United States, Committee on Chemical Engineering Laboratory, S. C. Ogburn, Jr., Bucknell University, *Chairman.*

Discussion of the Committee's report.

Leaders: Members of the Committee. W. L. Beuschlein, W. M. Cobleigh, J. C. Elgin, P. M. Horton, J. H. James, L. C. Jenness, H. McCormack, G. H. Montillon, J. H. Rushton, O. M. Smith, J. A. Webber.

Study of Laboratory Directions for Unit Operations Experiments Used at Various Schools, R. C. Kintner, Bucknell University.

Discussion. Leaders: Members of the Committee.

Tuesday

Chemical Engineering Laboratory Committee, in charge

9:30 A.M. Methods of Procuring Unit Operating Equipment for Chemical Engineering Laboratories. F. C. Vilbrandt, Iowa State College.

Designing Equipment for Unit Operations. Harry McCormack, Armour Institute of Technology.

Laboratory Methods and Equipment Used in Teaching Distillation. J. R. Withrow, and J. Koffolt, Ohio State University.

The Value of Industrial Inspection Trips to Chemical Engineering Laboratory Work. E. E. Randolph, North Carolina State College.

Discussion. Leaders.*

Symposium on the Desirability of a Laboratory Manual on the Unit Operations of Chemical Engineering.

W. W. Hodge, West Virginia University.

A. H. Weitz, Carnegie Institute of Technology.

Harry McCormack, Armour Institute of Technology.

G. H. Montillon, University of Minnesota.

M. C. Molstead, Yale University.

Discussion. Leaders.

8:00 P.M. 108 Chemistry Building.

Chemical Engineering Education Committee.

F. C. Vilbrandt, Chairman.

J. C. Elgin, Secretary.

Chemical Engineering Unit Processes in Lecture Instruction.

J. H. James, Carnegie Institute of Technology.

Laboratory Instruction.

S. C. Ogburn, Jr., Bucknell University.

Instruction in Non-Mathematical Phases of Chemical Engineering.

Ralph H. McKee, Columbia University.

Place of Undergraduate Research in Chemical Engineering Instruction.

F. C. Vilbrandt, Iowa State College.

CIVIL ENGINEERING

FRANK KEREKES, Iowa State College, *Chairman*

Monday

9:00 A.M. The Division as a Vital Unit in S.P.E.E.

C. C. Williams, President, S.P.E.E.

The Civil Engineering Division. Frank Kerekes, Chairman of Division.

The Objectives and Methods of Training in Civil Engineering. H. S. Rogers, Brooklyn Polytechnic Institute.

* To be selected at the time of the Conference.

Group Discussions:

Structural—Foundations and Soil Mechanics.

Soil Mechanics—A New Science. Fred. L. Plummer, Case School of Applied Science.

Research in Foundation Pressures. W. S. Housel, University of Michigan.

Discussion opened by S. C. Hollister, Cornell University.

Hydraulic-Sanitary—Basic Principles in River Hydraulics.

Model Studies on the Outlet Works of the Dams of the Muskingum Watershed Project. George E. Barnes, Case School of Applied Science.

Approaches to the Study of Bed Load Transportation by Flowing Water. F. T. Mavis, Iowa Institute of Hydraulic Research.

Discussion opened by Capt. Hugh J. Casey, Corps of Engineers.

Transportation-Surveying—Traffic Engineering Education.

Educational Adaptations for a National Mapping Program. Frederick H. McDonald, Consulting Engineer, Atlanta.

The Scientific Approach to Traffic Problems in Large Cities. Lewis W. McIntyre, Consulting Engineer, Pittsburgh, Pa.

Discussion opened by Charles A. Baughman, Alabama Polytechnic Institute.

6:00 P.M. Joint Dinner C.E. Division S.P.E.E. and Georgia Section A.S.C.E. Druid Hills Golf Club.

Toast Master: Frank Kerekes, Chairman, C.E. Division S.P.E.E.

Annual Address and Report, Chairman, C.E. Division, S.P.E.E.

Election of Officers and Executive Committee Members (S.P.E.E.).

Welcome to Georgia, R. P. Black, President, Georgia Section, A.S.C.E.

The Civil Engineer in the Construction Industry. Willard Chevalier, Vice President, McGraw-Hill Publishing Co.

The Status of Construction Engineering Education. F. W. Stubbs, Illinois University.

Tuesday, June 25

9:00 A.M. Engineers and the Problems of Highway Management and Operation. Roy W. Crum, Director, Highway Research Board.

Group Discussions:

Structural—Foundations and Soil Mechanics. F. P. Witmer, University of Pennsylvania, *presiding.*

Recent Developments in Soil Mechanics. Arthur Casagrande, Harvard University.

A Practical Soil Mechanics Laboratory. R. R. Philippe, Director Soils Laboratory, U. S. Engineer Office, Zanesville, Ohio.

Discussion opened by Frank Kerekes, Iowa State College.

Hydraulic-Sanitary—Basic Principles of River Hydraulics.

Certain Aspects of the Transportation of Sediment. Lorenz G. Straub, University of Minnesota.

The Teaching of Elementary Hydraulic Laboratory. Wallace Lansford, University of Illinois.

The Value of a River Hydraulics Laboratory in the Engineering Curriculum. K. C. Reynolds, Massachusetts Institute of Technology (to be presented in outline form).

Transportation-Surveying—Traffic Engineering Education.

Safety Factors in Highway Design over which the Engineer has Control. Lloyd F. Rader, and to be presented by H. P. Hammond, Brooklyn Polytechnic Institute.

The Introduction of Traffic Control Principles in Highway Courses. J. B. Butler, Missouri School of Mines.

Discussion opened by N. W. Daugherty, University of Tennessee.

8:00 P.M. Foundation and Soil Mechanics Courses in the C.E. Curriculum.

Demonstrating and Teaching Soil Mechanics with Models. D. P. Krynine, Yale University.

Undergraduate Courses in Soil Mechanics. Donald M. Burmister, Columbia University.

Graduate Courses in Soil Mechanics. LeRoy Tucker, Ohio State University.

Discussion opened by L. E. Grinter, A. and M. College of Texas, and F. D. Cooper, Columbus, Ohio.

COÖPERATIVE ENGINEERING COURSES

R. C. DISQUE, Drexel Institute, *Chairman*

Monday

9:30 A.M. Symposium: Coöperative Problems Presented by the New Political and Economic Condition.
F. E. Ayer, University of Akron.
F. A. Kartak, Marquette University.
C. A. Kapp, Drexel Institute.
C. S. Stone, President, Atlantic Steel Co.
G. T. Addison, University of Cincinnati.
H. N. Cummings, Newark College of Engineering.

Tuesday

9:30 A.M. Shop Work in the Coöperative Curriculum.
C. J. Freund, University of Detroit.
W. J. Stevens, Drexel Institute.
Coöperative Education in Textile Engineering.
C. A. Jones, Georgia School of Technology.

DRAWING

H. M. MCCULLY, Carnegie Institute of Technology, *Chairman*

Monday

9:30 A.M. Divisional Seminar meeting with a series of short papers discussing:
A. Drawing.
B. Descriptive Geometry.
C. Related Teaching Material.
D. Measurements.
E. Discussion of A.S.A. Standards Report.

6:30 P.M. Dinner Meeting. A guest speaker presenting the administrative viewpoint as it concerns Engineering Drawing and Descriptive Geometry.

Tuesday

8:00 P.M. Visual methods and models in teaching. Showing of motion picture films prepared by Justus Rising, Purdue University, and J. M. Miller, Rice Institute.

ELECTRICAL ENGINEERING

W. S. RODMAN, University of Virginia, *Chairman*

Monday

9:30 A.M. 1. Placement probabilities for electrical engineering graduates of the present and near future.

Needs of industry for technically trained men.
Training for other than central station or large industries.
Adequacy of present four-year electrical curriculum as preparation for the needs of industry.
Discussion: M. M. Boring, General Electric Co.
O. W. Eshbach, American Tel. & Tel. Co.
E. B. Roberts, Westinghouse E. & M. Co.

2. The Philosophy of text-book treatment and presentation of the subject of alternating current machinery.
Discussion: A. S. Langsdorf, Washington University. H. W. Bibber, Ohio State University.
3. How may the fundamentals of ionics be presented adequately in the regular curriculum?
a. At expense of time devoted now to electrical machinery?
b. At expense of time now devoted to other technical subjects such as hydraulics, mechanics, etc.?
c. By a five-year curriculum for the first degree?

ENGLISH

S. A. HARBARGER, Ohio State University, *Chairman*

Monday

9:30 A.M. Extent and kind of Literature Courses in an Expanding Engineering Curriculum.
From the Standpoint of the Profession. R. I. Rees, American Tel. & Tel. Co.
From the Point of View of the English Department. W. G. Perry, Georgia School of Technology.
From the Point of View of the College of Engineering. W. J. Miller, University of North Carolina.

Tuesday

9:30 A.M. Symposium: Writing Demands in the Four-Year Engineering Curriculum and the Responsibility of the English Department.
8:00 P.M. Shop Talk. A Round Table Discussion of Problems of Immediate Professional Interest to English Teachers.

INDUSTRIAL ENGINEERING

PAUL T. NORTON, JR., Virginia Polytechnic Institute, *Chairman*

Monday

9:30 A.M. The New Emphasis in Time and Motion Study. R. M. Barnes, University of Iowa.
Industry, Government and the Engineer. Geo. H. Shepard, Purdue University.
General Discussion.

Tuesday

9:30 A.M. Joint session with Mechanical Engineering.
Teaching of Engineering Economy.
Teaching the Cost Aspects of Engineering in Schools. E. D. Ayres, University of Wisconsin.
Engineering Economics, Why? Where? What? Geo. W. Barnwell, Stevens Institute of Technology.
A Course in Engineering Economics. D. B. Prentice, Rose Polytechnic Institute.
General Discussion.

8:00 P.M. Joint session with Mechanical Engineering and Machine Design, and Manufacturing Processes. R. M. Barnes, University of Iowa, *Chairman*.
Present Day Shop Methods and Their Evaluation.
C. A. Koepke, University of Minnesota.
A. A. Case, Georgia School of Technology.
O. W. Boston, University of Michigan.
N. F. Ward, University of California.
Discussion: F. L. Eidmann, Columbia University.
J. B. Finnegan, Armour Institute of Technology.

JUNIOR COLLEGES

R. A. WHITE, Grand Rapids Junior College, *Chairman*

Monday

9:30 A.M. Semi-Professional Courses in Junior Colleges.
Dinner Meeting. Discussion: Policies and Objectives for the Junior College Group of the Society.

Tuesday

Pre-Professional Courses in the Junior College.
9:30 A.M. Relations with the Senior College.

8:00 P.M. Semi-Professional and Pre-Professional Courses in the Same Institution.
The Problem of the Engineering Department in the Junior College.

MACHINE DESIGN

F. L. EIDMANN, Columbia University, *Chairman*

Tuesday

9:30 A.M. A Machine Design Course which Includes Kinematics. A. W. Luce, Lehigh University.
Discussion: V. M. Faires, Texas A. and M. College.
Requisites of a Teacher of Machine Design. G. F. Nordenholt, Editor, Product Engineering.

8:00 P.M. Joint Conference with Industrial and Mechanical Engineering, and Manufacturing Processes.

MANUFACTURING PROCESSES

R. M. BARNES, University of Iowa, *Chairman*

Tuesday

8:00 P.M. Present Day Shop Methods and Their Evaluation.
Methods at—
University of Minnesota, C. A. Koepke.
Georgia School of Technology, A. A. Case.
University of Michigan, O. W. Boston.
University of California, N. F. Ward.
Discussion: F. L. Eidmann, Columbia University.
J. B. Finnegan, Armour Institute of Technology.

MATHEMATICS

J. H. WEAVER, Ohio State University, *Chairman*

Monday

9:30 A.M. Concentric Transmission Lines. S. A. Schelkunoff, Bell Telephone Laboratories.
Mathematical Theory of Heat Conduction. R. V. Churchill, University of Michigan.
Application of Volterra's Functional Calculus to the Problem of Flow about an Arbitrary Aerofoil. J. G. Estes, North Carolina State College.
Applications of Mathematics to Electrical Engineering Problems. W. J. Seely, Duke University.

The Application of Operational Calculus to the Analysis of a Fuel Injection System. Benjamin Pinkel, Langley Field.

Tuesday

9:30 A.M. Method of Moment Distribution for the Analysis of Continuous Structures. Louis Brand, University of Cincinnati.

Application of the Theory of Matrices to the Theory of Electrical Circuits. R. S. Burington, Case School of Applied Science.

Report of Committee on Cooperative Tests.

Report on Placement Tests Carried on at Oklahoma A. and M. College. Herman Smith.

Report of Committee on Mathematics beyond the Calculus.

Discussion of the above reports.

MECHANICAL ENGINEERING

B. G. ELLIOTT, University of Wisconsin, *Chairman*

Monday

9:30 A.M. General Subject: Methods of Mechanical Engineering Laboratory Instruction.

Speakers: R. S. Howell, Georgia School of Technology.

L. M. K. Boelter, University of California.

General Discussion.

6:00 P.M. General Subject: Modifying the Mechanical Engineering Curricula To Meet Changing Social and Business Conditions.

Speakers: J. J. Wilmore, Alabama Polytechnic Institute.

H. F. Godeke, Texas Technological College.

C. E. Davies, Secy., Amer. Soc. of Mech. Engrs.

B. R. Van Leer, University of Florida.

Theodore Baumeister, Columbia University.

General Discussion.

Tuesday

9:30 A.M. Joint Session with Industrial Engineering.

The Teaching of Engineering Economy.

E. D. Ayers, University of Wisconsin, Teaching the Cost Aspects of Engineering in Schools.

Engineering Economics, Why? Where? What? Geo. W. Barnwell, Stevens Institute of Technology.
A Course in Engineering Economics. D. B. Prentice, Rose Polytechnic Institute.
General Discussion.

8:00 P.M. Joint session with Industrial Engineering, Manufacturing Processes and Machine Designs.
R. M. Barnes, University of Iowa, *Chairman.*
Present Day Shop Methods and Their Evaluation.
Methods at—
University of Minnesota. C. A. Koepke.
Georgia School of Technology. A. A. Case.
University of Michigan. O. W. Boston.
University of California. N. F. Ward.
Discussion: F. L. Eidmann, Columbia University. J. B. Finnegan, Armour Institute of Technology.

MECHANICS

A. E. NORTON, Harvard University, *Chairman*

Monday

9:30 A.M. What Time Shall Be Allotted to Basic Mechanics Courses in the Engineering Curriculum? W. J. Cox, Yale University.
Content of Courses in Fluid Mechanics. F. G. Switzer, Cornell University.

8:00 P.M. Dynamics in Industry. J. Ormondroyd, Westinghouse E. & M. Co.

Tuesday

9:30 A.M. Laboratory Courses in Applied Mechanics.
L. M. K. Boelter, University of California.
F. L. Everett, University of Michigan.
Vibrations. J. P. Den Hartog, Harvard University.

PHYSICS

G. E. GRANTHAM, Cornell University, *Chairman*

Monday

9:30 A.M. Adventure in Teaching Physics to Engineering Students. K. H. Fussler, University of North Carolina.
Physics Texts for Engineering Students. E. E. Bortell, Georgia School of Technology.

Physics Courses for Junior and Senior Engineering Students. A. A. Bless, University of Florida.

Most Efficient Use of Time Spent in the Laboratory. Percy Hodge, Stevens Institute of Technology.

Tuesday

9:30 A.M. Use of the Computation Section. D. M. Bennett, University of Louisville.

Physics the Engineer Should Know. O. W. Eshbach, American Tel. and Tel. Company.

Aims and Objectives of Physics Teaching in Engineering Colleges. D. S. Elliott, Tulane University.

Physics Laboratory Report. G. E. Grantham, Cornell University.

CONFERENCE COMMITTEES

Chemical Engineering: Frank C. Vilbrandt, *Chairman*, J. C. Elgin, W. W. Hodge, P. M. Horton, Ed. Bartow, O. L. Kowalke, J. R. Lorah, J. C. Olsen, E. E. Randolph, F. M. Shipman, V. T. Stewart, A. H. White, J. R. Withrow, John White, W. R. McCann, Ralph McKee, W. K. McAdams.

Civil Engineering: Frank Kerekes, *Chairman*, F. L. Plummer, *Secretary*, T. R. Agg, G. M. Fair, L. E. Grinter, K. C. Reynolds, D. M. Burmister, H. B. Compton, W. J. Cox, F. H. Derby, N. W. Dougherty, G. W. Holcomb, W. J. Emmons, T. E. Hubbard, H. T. Person, J. Vawter, D. M. McAlpine, L. W. Whitehead, J. H. Lucas.

Cooperative Engineering Education: R. C. Disque, *Chairman*, F. E. Ayer, F. A. Kartak, Geo. W. Burns.

Drawing: H. M. McCully, *Chairman*, Justus Rising, *Secretary*, W. E. Farnham, C. L. Svensen, Thos. E. French, E. F. Tozer, F. W. Ming, F. M. Warner.

Electrical Engineering: W. S. Rodman, *Chairman*, F. E. Johnson, A. C. Stevens, M. M. Boring, E. A. Bureau, C. L. Dawes, L. A. Doggett, W. H. Browne, A. C. Lanier, F. R. Pumphrey, T. W. Fitzgerald.

English: S. A. Harbarger, *Chairman*, W. O. Birk, J. R. Nelson, H. L. Creek, A. V. Hall, J. L. Vaughan, A. C. Howell, W. F. Scamman, C. F. DeLaBarre.

Industrial Engineering: P. T. Norton, *Chairman*, C. E. Bullinger, E. L. Grant, E. D. Hay, E. D. Smith, R. M. Barnes.

Junior Colleges: R. A. White, *Chairman*, J. C. Penn, A. G. Gehrig, F. C. Bolton, R. L. Sumwalt.

Machine Design: F. L. Eidmann, *Chairman*, V. M. Faires, C. W. Ham, Edgar MacNaughton.

Manufacturing Processes: R. M. Barnes, *Chairman*, R. L. Sweigert, A. P. Gwiazdowski. Continuation of conference on Machine Production.

Mathematics: J. H. Weaver, *Chairman*, R. S. Burington, H. L. Reitz, T. C. Fry, W. E. Brooke, W. J. Berry, Louis O'Shaughnessy, H. W. March, F. W. Bubb, B. F. Dostal, A. M. Dudley, H. A. Fisher, H. K. Fulmer, W. Paul Webber, E. J. Oglesby.

Mechanical Engineering: B. G. Elliott, *Chairman*, H. B. Dirks, J. J. Wilmore, F. W. Marquis, A. B. Domonske, O. A. Leutwiler, F. L. Eidmann, R. S. King, E. G. Hoefer, G. W. Munro, H. E. Degler, J. A. Dent, W. L. DeBaufre, H. F. Godeke, Edgar MacNaughton, R. C. H. Heck.

Mechanics: Zenas Bliss, *Chairman*, N. C. Ebaugh, H. L. Mason, Louis O'Shaughnessy, F. H. Switzer.

Physics: G. E. Grantham, *Chairman*, A. W. Duff, L. B. Spinney, R. B. Abbott, D. M. Bennett, C. C. Bidwell, J. B. Edwards, F. L. Brown, D. S. Elliott, J. O. Hamilton, Percy Hodge, H. S. Hower, G. M. Wilcox, H. L. Dodge, F. G. Slack.

NEW MEMBERS

ALLAN, WILLIAM, Instructor in Civil Engineering, College of the City of New York, New York City. Fred. Skene, H. P. Hammond.

BROWN, ORAL A., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa. H. J. Gilkey, Ben S. Willis.

BURMISTER, DONALD M., Instructor in Civil Engineering, Columbia University, New York City. J. K. Finch, Albin H. Beyer.

COLBERT, JULES P., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebr. O. J. Ferguson, T. T. Aakhus.

DAWSON, RAYMOND F., Testing Engineer, University of Texas, 2914 Beanna Street, Austin, Texas. T. U. Taylor, Banks McLaurin.

DILLS, CHARLES C., Instructor in Civil Engineering, University of Kansas, Lawrence, Kansas. Geo. C. Shaad, D. C. Jackson, Jr.

FLYNN, EDMUND C., Professor of Civil Engineering, University of Santa Clara, Santa Clara, Calif. Geo. L. Sullivan, F. L. Bishop.

HAINES, D. DON, Assistant Professor of Civil Engineering, University of Kansas, Lawrence, Kans. Geo. C. Shaad, D. C. Jackson, Jr.

HARPER, E. O., Chief Lubricating Engineer, Texas Company, Mortgage Guarantee Building, Atlanta, Ga. R. I. Rees, B. M. Brigman, D. B. Prentice, J. W. Barker, C. E. Davies.

HATCHER, THOMAS W., Associate Professor of Mathematics, Virginia Polytechnic Institute, Blacksburg, Va. Paul T. Norton, J. B. Jones.

LEHMANN, EMIL W., Professor and Head, Department of Agricultural Engineering, University of Illinois, Urbana, Ill. W. A. Foster, H. H. Jordan.

LETELLIER, L. S., Professor of Civil Engineering, The Citadel, Charleston, S. C. Re-instated.

MCLOUGHLIN, FREDERICK O. X., Professor of Civil Engineering, College of the City of New York, New York City. Harry Baum, J. C. Rathbun.

MORELAND, EDWARD L., Professor and Head, Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. D. C. Jackson, Carlton E. Tucker, G. C. Dahl.

MURRAY, WILLIAM A., Associate Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. L. S. Foltz, E. E. Kinney.

O'BRIEN, EUGENE W., Editor, *Southern Power Journal*, Grant Building, Atlanta, Ga. R. I. Rees, B. M. Brigman, J. W. Barker, D. B. Prentice, C. E. Davies.

OCKERBLAD, ANDREW M., Associate Professor of Applied Mechanics, University of Kansas, Lawrence, Kansas. Earl D. Hay, D. C. Jackson, Jr.

ROWE, C. E., Professor of Drawing, University of Texas, Austin, Texas. J. W. Ramsay, J. A. Correll.

SAWYER, WILLIAM L., Instructor in Civil Engineering, University of Florida, Gainesville, Fla. P. L. Reed, S. P. Sashoff.

SMITH, VERNE M., Instructor in Machine Construction, University of Kansas, Lawrence, Kansas. Geo. C. Shaad, D. C. Jackson, Jr.

STEINBERG, S. S., Professor and Head, Department of Civil Engineering, University of Maryland, College Park, Md. Re-instated.

STRINGHAM, R. B., Instructor in Electrical Engineering, University of Kansas, Lawrence, Kansas. Earl D. Hay, D. C. Jackson, Jr.

WALTERS, RAYMOND, President, University of Cincinnati, Cincinnati, Ohio. Re-instated.

WHITE, ALFRED M., Professor and Head, Department of Chemical Engineering, University of North Carolina, Chapel Hill, N. C. W. J. Miller, G. W. Smith.

YOUNG, WILLIAM M., Research Engineer, Taylor Instrument Co., 95 Ames St., Rochester, N. Y. H. L. Mason, C. L. Svensen.

REPORT OF THE TREASURER

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

STATEMENT OF CASH ACCOUNT

JUNE 17, 1935

BALANCE ON HAND—June 13, 1934		$ 3,152.95
RECEIPTS:		
Current Dues	$ 9,949.20	
Back Dues	999.25	
Dues in Advance	177.00	
Sales of Publications	591.68	
Advertising	1,509.80	
Miscellaneous Income	1.05	
Refund by Summer Session account for Conference Expenses paid by S. P. E. E. (In full for 1934 S. S.)	290.99	
Refund by Carnegie Fund for Loan made in 1933–34	200.00	13,718.97
Total		$16,871.92
DISBURSEMENTS:		
Cost of Publications	$ 5,001.40	
Cost of Proceedings	390.07	
Honorarium for Secretary	1,200.00	
Salaries—Secretary's Office	3,300.00	
Traveling Expense—Secretary's Office	303.25	
Committee Expenses	79.35	
Printing, Postage, Office Supplies, Etc.	738.17	
Expenses—1934 Meeting	535.52	
Expenses—1935 Meeting	352.98	
Dues—American Council on Education	100.00	
Dues—American Engineering Council	250.00	
Contribution to A. S. M. E. for Report on Drawings and Drafting Room Practice	200.00	
Temporary advance during current year for account of Summer Session Conferences (Part for 1934 Session and part for 1935 Session)	250.78	12,701.52
BALANCE ON HAND—June 17, 1935		$ 4,170.40

Note—In addition to the above balance, there is on deposit at the Forbes National Bank, Pittsburgh, Pa., in savings account 3809 the amount of $6,000 with interest of $972.31 to June 1, 1935.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

BALANCE SHEET

JUNE 17, 1935

ASSETS

Cash:		
Current Fund	$ 4,170.40	
Petty Cash Fund	300.00	
Life Membership Fund	767.37	
Benj. G. Lamme Fund	155.63	$ 5,393.40
Savings Account:		
Forbes National Bank—No. 3809		6,972.31
Securities:		
Benj. G. Lamme Fund		5,000.00
Prepaid Expenses—1935 Meeting		352.98
Inventory		
Accounts Receivable:		
Current Dues	$ 240.00	
Advertising	253.50	
Lamme Medal Fund	900.00	
1935 Summer Session Conferences	31.19	1,424.69
Furniture & Office Equipment (Est.)		100.00
		$19,244.38

LIABILITIES

Life Membership Fund		$ 767.37
Benj. G. Lamme Fund		5,155.63
Prepaid Membership Dues		177.00
Accounts Payable		500.00
Surplus Account:		
Balance at June 13, 1934	$10.878.49	
Reimbursement by Carnegie Fund for advance charged off during the year 1933–1934	200.00	
Surplus for the present year	1,565.89	12,644.38
		$19,244.38

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

INCOME AND EXPENSE STATEMENT

For the Year Ending June 17, 1935

EXPENSE

Cost of JOURNAL	$ 4,652.35
Cost of *Proceedings*	390.07
Expenses—1934 Meeting	700.06
Honorarium for Secretary	1,200.00
Salaries—Secretary's Office	3,300.00
Printing, Postage, Office Supplies, Etc.	738.17
Traveling Expense—Secretary's Office	303.25

Committee Expenses	79.35
Dues—American Council on Education	100.00
Dues—American Engineering Council	250.00
Contribution to A. S. M. E. for Report on Drawings and Drafting Room Practice	200.00
	$11,913.25
Surplus for the Year	1,565.89
	$13,479.14

INCOME

Current Dues	$10,347.70
Back Dues	759.25
Sales of Publications	663.08
Advertising	1,364.98
Miscellaneous Income	1.05
Interest on Savings Account	343.08
	$13,479.14

REPORT OF THE SECRETARY, 1934–35

F. L. BISHOP

Introduction

It is the duty of the Secretary at this time to present to the Council and to the Society a report covering the "state of the Society." In the present report I am "Looking Ahead" and I wish to call to your attention and for your consideration certain changes in engineering education which are quite familiar to you but which involve to a certain extent changes in the character of the work done by the Society. Among these changes which affect the work of the Society are: (1) accrediting engineering colleges; (2) junior colleges and technical institutes; (3) graduate work and research. It should, however, be borne in mind that the basic conception has been and still continues to be the four-year undergraduate course in engineering and the improvement of these courses is the major problem of the Society.

Accrediting Engineering Colleges

The accrediting of engineering colleges has been one of the problems which has confronted especially the national engineering societies, state boards of registration and other bodies which give credit in one way or another to graduation from a recognized or accredited school of engineering. This Society has consistently refused, and I think wisely, to attempt to accredit engineering colleges. However, the Council, at its meeting at Cornell in June, 1934, approved the Engineers Council for Professional Development as the accrediting agency for engineering colleges. This work is progressing and a detailed report will be presented to you by one of your representatives on the E. C. P. D.

Junior Colleges

Of primary importance is the very rapid growth of pre-engineering courses in junior colleges involving a factor which may change the character of the courses in the last two years of those four-year engineering schools located in the district where there are a large number of junior colleges.

* "The report of the Secondary School Survey indicated that

* May 1935 *Journal of American Association of University Professors.*

there had been a slowing down in the number of junior colleges. Walter C. Eells has pointed out that the number of junior colleges has increased from 405 in 1929 to 528 in 1935, 30 per cent increase, while enrolment has risen from 54,438 in 1928 to 110,118 at present, an increase of more than 100 per cent.

"While the resident student enrolment in degree-granting institutions has increased a little less than three-fold in fifteen years, that in junior colleges has been multiplied nearly nineteen times. In 1917–18 it was less than two per cent of the total; in 1931–32, eleven per cent."

Papers on the junior college subject have been presented at different times before the Society for a number of years but, beginning with the Purdue meeting in 1931, the subject has been on every program. The first conference on junior colleges was held at the Corvallis meeting in 1932. At the 1934 meeting at Cornell there were fourteen papers presented on this subject. Two half-day and two evening Conferences are scheduled for this meeting.

It is obvious that a close coöperation should exist between the junior college and the senior college. It is for this reason that the Executive Committee has submitted to the Society the proposed changes in the Constitution and By-Laws to admit junior colleges as institutional members of the Society.

Of equal importance are the technical institutes which bear perhaps a more direct relation to engineering education. The cooperation between these and this Society has at all times been close. Conference groups of technical institutes have held frequent meetings and numerous papers pertaining to technical institutes have appeared in the JOURNAL OF ENGINEERING EDUCATION. A supplemental study of the investigation of engineering education was made of technical institutes under a special grant from the Carnegie Corporation supplemented by individual subscriptions. The proposed amendments to the Constitution would make these institutes an integral part of the working organization of the Society.

GRADUATE WORK AND RESEARCH

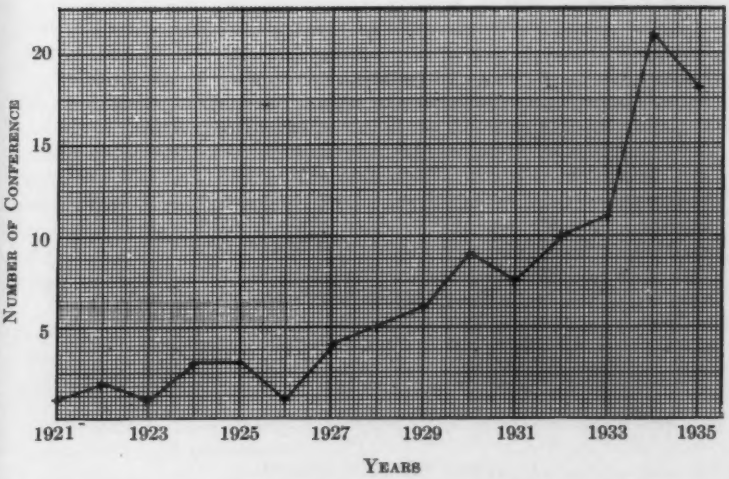
On the other side there is graduate work and research which in recent years have been rapidly expanding. It is interesting to note that the Board of Investigation and Coördination did not make a special detailed report in regard to graduate work being done in engineering colleges. This was undoubtedly due to its relatively small importance in the engineering educational field at the time the investigation was made. Plainly, the convention procedure and the work of this Society, which related to undergraduate curriculum only until recent years, had to be supplemented to care adequately for these innovations.

The work of the committees on graduate work and on research over the past few years has been of outstanding value and interest. Their importance in the work of the Society has been increasing and their effect on the work in different institutions has undoubtedly been very important as I know of one large university which reorganized its graduate work along the lines recommended in the preliminary report of the graduate committee. At this meeting we shall devote one session to the presentation of this committee's work under the chairmanship of Professor H. P. Hammond.

Conferences

The conference method of meeting and discussing problems common to certain groups was established in the Society in 1921 when, in connection with the meeting of this Society at Yale University, the Deans met and formed the Division of Deans and Administrative Officers. Meetings of this group were held each year until 1928 when it was merged with the Institutional Division.

The following curve shows the growth of these conferences since they were first organized in 1921:



The keynote of this meeting is "Looking Ahead." This curve was originally prepared with that in mind and while the Secretary has no desire to pose as a prophet it would seem that the number of conferences will range between 20 and 25 at our annual meetings.

We have not given up hope of being able to organize summer schools for engineering teachers similar to those operated so efficiently by Professor Hammond. Meanwhile, it is hoped that these conferences may, to a certain extent, take the place of the summer schools and it was with this in mind that President Wickenden worked so energetically and successfully in promoting the conferences held last summer at the Cornell Meeting.

Another important factor enters into the matter of conferences which I have never seen expressed better than in a letter of President Williams. I quote in part from it:

"Until a few years ago, S. P. E. E. conventions envisioned engineering education as the administration of undergraduate classes only. Today, these two factors, research and graduate study, which require altogether different techniques and procedures, form an inevitable part of the educational program. At the Atlanta convention one-half day each will be given in the main program to Undergraduate Education and to Graduate Study, and to Research as an Instrumentality in Engineering Education. Many have thought of research only in terms of the results to scientific knowledge, but its value as a device for education perhaps is even greater."

"S. P. E. E., following a policy of academic freedom, so to speak, has permitted enthusiastic groups to organize divisions in special fields. These 'divisions' have usually been a rather natural flowering of corresponding predecessor committees. At present there are divisions as follows: Civil Engineering, Engineering Drawing, Machine Design, Coöperative Engineering Education, Mechanics and Institutional. Other branches and interests operate committees. The enthusiastic interest, particularly, amongst the younger members, which these conferences elicit, is a matter of common remark, and similar group conferences have recently characterized the local section programs. That such homogeneous group meetings meet a real need is evidenced overwhelmingly."

The work of some of these divisions, through the conferences at the annual meeting and the committee work throughout the year, has not only modified the work in their own fields but have in some cases materially modified the engineering curriculum.

Sections and Branches

The growth in the number and activities of sections and branches of the Society indicates a healthy vigor in the organization as well as enterprise and spirit on the part of the members and offers an ideal opportunity to interest non-members in our activities. President Williams and Chairman Thatcher, in the May

JOURNAL, present two editorials on sections and branches. The following figures and map are taken from the report of the Committee on Sections and Branches made last year. We have added two new sections this year—Illinois-Indiana, and Iowa-Wisconsin. Chairman Thatcher will report in detail at this meeting.

The report from the secretary of each section and branch is printed in the JOURNAL together with one or more papers from each meeting, thus making the section meeting not only local but national in character.

The entire country is now covered by sections, thus each member becomes automatically affiliated with a local section. Due to the publication, in the year book, of the geographical distribution of the members by states, it is a simple matter for the secretary of the section to obtain the names and addresses of all members living within the territory which his section covers.

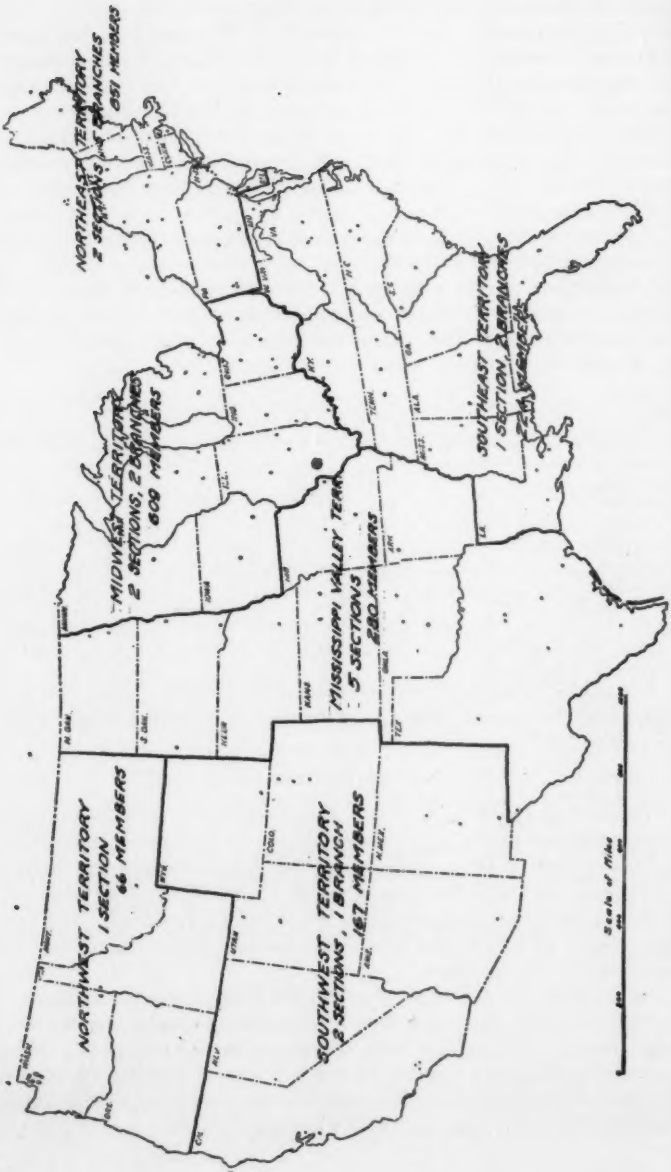
Territory	Members	% of Total	Sections	Branches	Reported Meetings	Attendance
Northeast	851	38.8	2	5	8	425
Southeast	224	10.2	1	2	3	75
Midwest	609	27.7	2	2	9	245
Miss. Valley	280	12.7	5	—	3	250
Northwest	66	3.0	1	—	1	75
Southwest	167	7.6	2	1	1	50
Total	2,197	100.0	13	10	25	1,120

"A study of sections and branch meetings held during the past year (1933–34) shows that approximately 50 per cent of our members attended."

PUBLICATIONS

Council at the 1934 meeting dissolved, at its own request, the Board of Investigation and Coördination. The second volume covering the report of the investigation was issued during the current year under the editorial direction of C. F. Scott. He also prepared an excellent abstract which was widely circulated. The complete report of this Board is now available in two volumes and has been sent to all members.

A synopsis of the papers presented before the conferences at Cornell was published and each conference chairman was asked to select one or two papers for publication in the JOURNAL. Many extraordinarily good papers we were unable to publish because of the lack of space. Desirable material is always available for at least doubling the size of the JOURNAL.


NORTHEAST TERRITORY
2 SECTIONS, 3 BRANCHES
851 MEMBERS
MIDWEST TERRITORY
2 SECTIONS, 2 BRANCHES
609 MEMBERS
MISSISSIPPI VALLEY TERR
3 SECTIONS
280 MEMBERS
SOUTHEAST TERRITORY
1 SECTION, 2 BRANCHES
NORTHWEST TERRITORY
1 SECTION
66 MEMBERS
SOUTHWEST TERRITORY
2 SECTIONS, 1 BRANCH
167 MEMBERS
Scale of Miles

The Publication Committee each year provides space in the JOURNAL for the President of the Society to present his views in regard to engineering education and the work of the Society, so that the contributions made by each president automatically become a record. I recommend to your reading the editorials by President Williams.

EMPLOYMENT SERVICE

The Secretary's office sent a letter to each dean of engineering asking him to list with this office the vacancies which he had or which he expected to have for 1935–36. Many institutions gave hearty coöperation in this work while others, perhaps as a matter of policy, did not. We have many more requests for positions than we have positions to be filled. Quite a portion of this work is confidential especially when positions are being filled in regard to professors and administrative officers.

COUNCIL ACTIONS DURING YEAR

The following actions have been taken by Council since the last meeting at Cornell:

1. 175 new members have been elected to membership.
2. Two new sections have been approved—Illinois-Indiana and Iowa-Wisconsin.
3. A Progress Committee was appointed consisting of C. F. Scott, Chairman, M. L. Enger, E. A. Holbrook, R. H. Fernald, and A. H. White. The function of this Committee is to report annually, to the Society, the outstanding achievements in engineering Education in the year.

MEMBERSHIP

We now have a membership of 2364, of which 168 were elected by letter ballot and 25 at this meeting. It is interesting to note the distribution of these new members as of May 23, 1935:

North of Mason & Dixon Line and East of Miss. River	75 = 41.66%
South of Mason & Dixon Line and East of Miss. River	29 = 16.11
West of Mississippi River	73 = 40.55
Canada 2, Australia 1	3 = 1.61

President Williams was Chairman of the Membership Committee, one member being appointed in each institution. Very satisfactory results were obtained by this method and I believe this is a desirable procedure for securing new members.

Engineering Enrolment

The Office of Education has asked the Society to take over the securing each year of enrolment in engineering colleges. A survey made last fall by the Society indicates that there was an increase in attendance, especially in the freshman class. This has an important bearing on the work of this Society because of the fact that its membership is composed largely of teachers in engineering colleges. While the attendance was holding stationary or decreasing and the financial situation was such that many salaries were reduced and a number of teachers were of necessity obliged to secure work in other fields, the problem of maintaining the activities of the Society became difficult. During this period, however, the Society has been able to increase its activities and to keep its financial condition satisfactory.

General

The Society has coöperated with other engineering societies particularly through the American Engineering Council, the American Council on Education, and the Engineers Council for Professional Development.

There has been considerable agitation at different times for a certificate of membership and for a pin. Council at Cornell instructed the Executive Committee to prepare a certificate for presentation at this meeting. A form has been prepared and will be presented to Council for action before presenting it to the Society. A design for a pin has also been made and is being submitted.

Many communications come to the Secretary's office pertaining to the relation of engineering education to other fields. This is illustrated by the receipt, this year, of two letters in regard to the relation between the engineering graduate and his admission to law schools.

A valuable contribution that could be made to engineering education would be an up-to-date index of the *Proceedings* of the Society. The matter has been studied at various times by the Executive Committee and the cost found to be excessive. President Williams has had this matter under consideration and I think possibly he has a solution which could be borne financially by the Society.

The report of the Treasurer, W. O. Wiley, will be in the form of an audit and will show the finances of the Society in a satisfactory condition.

The practice established when Dean Kimball was President of the Society of holding an informal meeting at the time of the meeting of the Land Grant College Association was continued during the current year with a meeting at Washington in November.

This has proved an excellent opportunity for the officers of the Society to obtain an expression of opinion in regard to various policies which the president of the Society wishes to carry out.

There is being submitted at this meeting the following changes, one in the Constitution and one in the By-Laws of the Society. The Executive Committee feels that with the adoption of these the work of the Society would be more effective.

ARTICLE II of the Constitution reads as follows:

Institutional members shall be educational institutions giving instruction in engineering. They shall be represented at all meetings of the Society or its divisions by regularly appointed delegates, one for each institutional member concerned.

To be changed to read:

Institutional members shall be educational institutions giving instruction in engineering and shall be of two classes, active and associate. The active institutional members shall be recognized institutions giving baccalaureate or equivalent degrees for curriculums in engineering. The associate institutional members shall be other educational institutions giving instruction in engineering. Institutional members shall be entitled to representation at all meetings of the Society or its divisions by regularly appointed delegates, one for each institutional member concerned.

BY-LAWS, Second, reads as follows:

The President, the Secretary, and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

To be changed to read:

The President, the two Vice-Presidents, the Secretary, and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

Article X of the Constitution reads: This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the Society, provided that all members have been notified of the proposed amendment by notices mailed from the Secretary's office at least 30 days prior to the regular meeting at which action is had, and provided that the amendment shall have been approved by the Council by a two-thirds vote of the members voting by letter or voice.

Article Nine of the By-Laws reads: Additions or amendments may be made to these By-Laws at any regular meeting of the Society by a two-thirds affirmative vote of the membership present at the business session, provided that the additions or amendments shall have been approved by a two-thirds affirmative vote of the Council membership in attendance at the meeting, and shall have been recommended by that body for adoption.

OBJECTIVES OF ENGINEERING EDUCATION

By DUGALD C. JACKSON

Massachusetts Institute of Technology

"See this our garden,
Large and fair!"

1. *Introduction.*—From time to time heretofore, and now again, the stability of the American organization of federal and state governments has depended on the judicial wisdom of the federal Supreme Court in holding legislative and executive powers to their constitutional anchorages. In this significant present decade the contests that lie before us partly range around the effects introduced by the extended use of machinery, the expansion of manufacturing industries, revolutionary changes in transportation, the production and distribution of electric power, and other engineering activities. Engineering progress is directly involved. We, therefore, are enjoined to " look ahead," as President Williams has proposed.

The status and the progress of engineering education are of peculiar importance in this juncture. It is a primary duty now to review the objectives of engineering education. The two-volume report to this Society of its Board of Investigation and Coördination points out, as Chairman C. F. Scott suggests, " where we are and the way we have come," which makes it easier to determine " where to go from here." We still have to study our trends and be sure that they are aimed toward correct objectives. In respect to the past and the present I commend you to read from Vol. II of the Report of the Board of Investigation and Coördination the Final Report of the Chairman which gives a summary of the results of the investigation.

Even with this outline of the past and present before us, how many of us have mentally formulated for engineering education those objectives which seem to be sound and sufficient and which we are endeavoring to approach? We have in mind a lot of details. We have established ways of carrying on. We know that a capable scientist, engineer, or inventor exercises some or all of the following qualities: Discriminating powers of analysis with which to guide exploration; Imagination for arousing visions of a "promised land"; Curiosity for inciting experimentation; Penetrating powers for observing results of analysis or experiments;

and Synthetic Intelligence to support invention. This also carries with it the recognition that it is not only knowledge which we wish to provide for our students,—that consists of facts and interrelations which are known and of techniques which go along with observing those facts and interrelations,—but primarily we seek to cultivate through engineering education an aptitude in our students for the useful employment of their knowledge in human affairs.

The topic which President Williams asked me to treat is "Objectives of Engineering Education." The phrase is without a definite article and I therefore have interpreted it to relate to objectives that are now importunately pushing forward but have not been universally accepted. Such objectives are in addition to those relating to technical capability of students and alumni. It is accepted generally that the technical capabilities of our students in matters of detail usually are well brought out and developed. Criticisms of engineering education and its effects usually relate to other features.

Engineering varies in all epochs according to the states of science and experience. Engineering education therefore cannot be static and fulfill its functions, because both science and experience are in a constant flux of progress. Accordingly our educational objectives must be reviewed and revised from time to time in order that synchronism with reality may be maintained. We can never reduce the importance of preparation for technical achievement that is an everstanding and primary objective of engineering education, but other objectives are open to modification and supplementary ones are open to adoption. Of these, it seems to me that the following five now need our fuller attention: (1) Development of specific personal qualities in students; (2) Introduction of sound and comprehensive thinking in the economics and sociology that relate to our field; (3) Stimulation of creative intelligence conjointly in management and in ability for scientific research; (4) Securing of coöperation in faculties between the engineers and the economists and sociologists of as great intimacy and soundness as now exists between the engineers and the mathematicians, physicists and chemists; (5) Securing breadth in the education of our students by insisting on rich and scholarly intellectuality in the engineering field as an essential quality of every mature member of our engineering teaching personnel.

We teach a process which is threefold: First, Analyze by either experimental (observational) or mathematical procedure for securing the facts and relationships in any case, whether they are new or already partly known; second, Systematize the data secured

so that we may study and understand the relationships adequately; third, Summarize, so that the facts and their relationships may be set forth in a concrete embodiment, whether expressed in words or as a plan or a construction. However, in respect to this teaching, can we all answer an emphatic affirmative to searching questions regarding our methods such as the ten set forth in my address at Lehigh University in 1930? *

Whatever may be our personal answers to those questions at the moment, in my ensuing discussion of the grounds for selecting the five objectives I will assume that we all approve the affirmative aspect of the ten points.

2. *Qualities Needed by an Engineer.*—Before the objectives of engineering education can be set out with any clarity, we must have a clear perception of the mental and physical qualities that are needed to support the activities which ought to pertain to an engineer's life. These have been discussed in the meetings of this Society ever since the Society was organized; but, as Sancho Panza says, "Many words won't fill a bushel." Most people say that personal qualities take precedence of technical information and competency. Granted,—but what are the "personal qualities"? The reply usually is Character, first; then, Personality; then, Health. But, what is meant by "character"; what is meant by "personality"? There the conversation usually stalls. The supposed conversation illustrates the inadequate and often inexact use of terms which is not unusual when dealing with this topic. The same vagueness is likewise illustrated by the not uncommon description of engineering as a "state of mind" or a "special culture," which are pleasing phrases but too vague to be informative. A good deal of such discussion is as fruitless as fishing for mushrooms at the bottom of the ocean.

I will confess that such vagueness or ambiguity is not confined to the discussion of human qualities. A recent discussion with a colleague regarding the proper manner of defining the "charge" in an electrical condenser led to our discovering that a large proportion of textbooks on physics formulate their definitions of this important phenomenon so that they are either unintelligibly vague or else ambiguous. One difficulty in deriving sound and intelligible definitions is caused by insecurity of the mutual relations of the respective spheres of words and of physical things. This is illustrated by the fact that a speech of many words may sound very

* "What the Technical Schools Expect of Industry." Address delivered on the occasion of the dedication of the James Ward Packard Laboratory of Mechanical and Electrical Engineering, Lehigh University, Oct. 16, 1930, *Science*, Vol. LXXII, 1930, pp. 637–642.

well to an audience but proves on analysis to mean very little in fact.

"What qualities are needed by an engineer?" is a practical question.* We must rely upon experience for the answer, but some guide to interpretation of experience may be found in *a priori* reasoning. For example, we know from experience that what we call "character" includes intellectual as well as physical (financial) honesty. We also know that many who possess impeccable physical honesty are intellectually dishonest. The latter people we infer to be incapable of facing courageously unpalatable facts. The professional reformer in politics who proves willing to use misleading or shady means in producing a good end is of this type. Such men are dangerous to the social organization. They are congenitally unable to deal with nature and her rigors and therefore are poor engineers; but they often are persuasive (although unsound) politicians.

In addition to intellectual and physical honesty, the word character connotes the tenacity of purpose that leads its possessor, who has put his hand to the plow, to carry through to the end of the furrow. Mental courage has much to do with this quality. Other needed qualities are mental initiative, originality of mind, sense of responsibility (which is associated with tenacity of purpose), patience (also an offspring of tenacity of purpose), self-reliance, judgment (which is the child of keen observation and a sense of the relative fitness of things), tolerance and openmindedness, enthusiasm, imagination, and generosity of spirit which offers and secures coöperation. To make a good engineer one must possess active intelligence, unshakable integrity, tested patience, and tenacity of purpose for "carrying through."

Some students have never learned the art of sound thinking,—*i.e.* of putting 2 and 2 together so that the result is 4, exactly, instead of a little more or a little less. Such ones sometimes rather pride themselves on their defect, and appropriate to themselves the unauthorized title of reformers. An effort to bring them into the preferred realm of sound thinking in which engineers are expected to live is like a stranger's effort to enter a well-populated bird cage without setting the birds into excitedly throaty expressions.

Tenuous thinking also indicates unsound imagination; while a fertile imagination, held definitely to face realities as a plane of origin, is a major tool of engineers. Indeed, a self-styled engineer who is without imagination is not an engineer. He is an artizan. From the modern standpoint, kingship is not a divine right, but

* The Appendix gives a tentative list of particularly needed qualities, along with their definitions, prepared by Mr. John M. Nalle, Placement Officer of M. I. T.

we assert that creative imagination is. Curiosity, interest, the intellectual joy of achievement associate equally with all imaginative productions. Imagination is born with us. It also may be planted and cultivated.

The qualities of optimism and pessimism often have been discussed, with optimism extolled and pessimism deplored; but such discussions arise from a narrow and incomplete conception. The sound and socially fruitful human being needs a combination of the two qualities. Imagination coupled with optimism arouses visions which are pictured as capable of actual embodiment, but the restraining influence of pessimistic historical hindsight is necessary to prevent overoptimism leading on to a crash.

Observation, experiment, and logical reasoning are the prime intellectual tools of the engineer; but engineering should contribute primarily to economic welfare of communities or groups, and any leading engineer therefore must possess personal qualities which enable him to interpret social relations and also enable him influentially to express his opinions for laymen to absorb. Men may try to cover over their ignorance by the flow of many words, but the covering medium usually is transparent as thin glass and the inadequacy ultimately is disclosed. For illustration, you may enumerate the parts of an automobile and still not explain what an automobile is, the assembly of the parts being different from the parts themselves, in imagination, in language and in fact.

An acquaintance with nature can be secured only by observation and experiment. Out of such efforts we get the simple facts upon which we rely. The interrelationships of the facts often may be indicated by logically exact reasoning, and here mathematics makes its most useful contributions. Following power in observation, in experimenting, and in logical reasoning comes facility in the arts of expression (convincing language, drawing and competent interpretation of drawings) in the primary spectrum of engineering capacities. And finally, out of experience with it all may be cultivated a penetrating judgment and a thorough-paced sagacity.

Unhappily, in our present procedure we do not effectually get these matters into the minds of all of our students. If we did, there would be less flighty thinking, such as is observable even among students of engineering schools. Thus, if American college students would sharply challenge the views of every self-seeker or demagogue who runs for public office in the students' respective and individual districts our government would soon live on a higher ethical plane. This would be a fine substitute into which to pour the energy which now goes into talk of "strikes" to enforce crude opinions, and the like. Much froth would thereby be replaced by sound procedure.

Engineering usually does not bring great wealth to its practitioners but it affords opportunities for professional services which bring a sufficient money compensation and coveted prestige. To observe progress making its way and to participate in its processes additionally contribute to the recompense. However, we would be foolish not to admit with Cervantes, that "The brave carve out their fortunes, and every man is the son of his own works." Unless the neophyte engineers come to realize the truth of this proverb while they still are students, employers will find that their present-day common criticism continues to be applicable, namely, that engineering school graduates as they come forth are well informed in technical details and can adequately carry out bits of work under direction, but that they are not suitably competent to attack comprehensive problems independently and are incapable in the personal relations and persuasive arguments such as are proper parts of business affairs.

The needed personal qualities cannot be created objectively by lectures, classroom exercises, or closely-directed laboratory work. They must grow subjectively out of the efforts of the students themselves, to which growth lectures on the scientific topics in the students' field, sympathetically supervised engineering problem work, laboratory investigations, and conferences with teachers may greatly contribute while also establishing the needed scientific and technical knowledge and techniques. Accomplishing this process more effectually may be set down as one of the objectives that we should recognize and for which we should strive.

3. Wider Research Needed in Engineering Education.—Perhaps we ought here to have a definition of the word research. A definition which I formulated some years ago, when needing for my own purpose a clearer statement than is usually given, is the following: "Research is the process of detecting and identifying facts and discovering their varied relationships." This is clear, straightforward, and covers the scope of the word accurately. As I pointed out in an address at the Purdue Convention of this Society,* properly directed research is a potent instrument for arousing the ambitions and for exercising the reasoning powers of students. It also teaches them to use foresight in planning. It exercises the sense of responsibility for "carrying through." Besides which it possesses several other notable features of advantage associated with our purpose. American undergraduate college students are young men who should have individual ambitions and purposefulness, and they are well along toward intellectual maturity before

* "The Function of Research in Engineering Education." *Proceedings of the S. P. E. E.*, Vol. XXXIX, 1931.

they graduate. The processes of research should therefore, while they are students, become their handmaiden if they are to become engineers. Most of the great scientists and engineers of the preceding generation came to their distinction after an education in observation and experience relating to matter available at their day, and we should be very cautious about substituting, for our engineering students, philosophical studies (as we tend to do by means of our textbooks) in place of physical research studies.

Investigation calls for the application of the fullest resourcefulness and initiative that can be brought to bear, and the application of constant resourceful improvisation in the use of methods and apparatus. These are processes alike pertaining to success as pure scientist, engineer or physician. Controlled curiosity and constructive-mindedness go hand in hand in hand as qualities needed by the engineer, and the investigative process applied to engineering problems links them together. Chance discoveries are sometimes made in science. However, in engineering we cannot rely on chance but must depend on rational reasoning as far as we can, in spite of the "gypsy voice of nature." Empiricism comes in with propriety only where fundamental science is not available. It is an intrinsic concept of modern science that incompleteness of knowledge is due to insufficiency of the yet achieved investigations into the reasons of things.

Here is where the economists, and in even greater degree the sociologists, are in difficulty, for exact data for them are so hidden behind a barricade of allegations and assumptions that it is very difficult in their field to carry on an investigation which detects and identifies the unmixed facts and thereby clears the ground for discovery of the varied individual relationships of which it is necessary to have knowledge before exact conclusions may be drawn. I think that it is this condition that has thrown sociology largely into the lap of wishful (as distinguished from exact) thinking. Economics is partly in the same status. It has been remarked that "barley is just as good a grain as sesame, but 'open barley' would not open the door of Ali Baba's cave, whereas 'open sesame' would." This is an illustration of the dominating influence sometimes assumed by specific differences, and such differences are often to be regarded with as much respect as generic differences. We can give recognition to this in the physical sciences, but this situation makes one additional difficulty for the economists and sociologists.

Even in the physical sciences it is difficult to put our finger on any fact which is *ultimate*. Each fact that has been named as an ultimate fact turns out to be specified by reasoning from relationships and not by direct observation of the phenomenon, or it may be partially based on inference and assumptions. Nevertheless,

our engineering training helps us to distinguish between specific differences and generic differences, even in very complex situations, and therefore we should be able to aid in untangling some of the difficulties in economics and sociology. Eminent features of present-day civilization that are the off-spring of engineering activities have been called to the bar of public opinion and accused (unjustly and in ignorance, in my opinion) of causing economic difficulties and unfair social disparities. This is a challenge to engineering education. Our work holds us to a primary responsibility for the effects of the development of vast manufacturing interests, convenient transportation, quick intercommunication, useful power transmission, improved artificial lighting, potable water supplies, and enlightened sanitation,—all of which have contributed to the spirit which supports increased population densities and the congregation of populations in notably dense urban centers. We are proud of our offspring and stand warrantors of their serviceability to society. They have brought increased emphasis for human intelligence in contrast to brutality and have transferred physical labor from human shoulders onto machines; and they have added much to the assurance of life and comfort (as well as happiness) in living. If effects of these offspring have been wildly misapplied, as has been charged, we could deny responsibility, but that would exhibit a faint-heartedness that we refuse to admit.

There is no prison for adolescents, or reform school, in which the growing offspring of our work may be restrained without causing sacrifice of many of the comforts and conveniences now enjoyed by humanity. If there were, it would be our duty to participate in the management. As it is, we have a duty to assure that our creations that arise, and that have arisen, through engineering application of science shall not be used for the disservice of humanity, and along with that to aid in making social development honest and sound. To fulfil this duty will require of us sound and comprehensive thinking in the economics and sociology relating to our field, such as we have not yet introduced into our teaching; and also will require the establishment of research therein of a kind which fulfils the definition of research heretofore referred to. The situation is a challenge to engineering education. To meet the need effectually is now an objective of primary magnitude. Scientific discovery and invention, out of which have grown our greatest engineering activities, are still in their frontier and pioneer stage and they are under attack by those who appraise their effects carelessly or ignorantly. To meet the situation requires sound-thinking and creative imagination. Engineering ought to be to every one of its practitioners what it has been to a few,—a joyous life of successful creative effort expressed either in material struc-

tures or in effective administration, carried out with thoughtful consideration of producing a favorable effect on the social organization. It is needful to seize this problem by the tail and hang on until the solution is secured.

4. How Engineering Enters into Civilization.—I discussed this question in a popular way in a Vice-Presidential address of the A. A. A. S. entitled "The Origins of Engineering."* That article contains such evidence as archeology and history afford. Though not equally serviceable as evidence of the antiquity of engineering, you may be interested to be reminded of the popular view as sung by Kipling,

> "When the waters were dried an' the earth did appear,
> The Lord, he created the Engineer."

To understand the influence of engineering on civilization we must view history and prehistory through the eyes of archeologists rather than the eyes of professional historians, but we may secure the fullest delineation by utilizing the aid of both archeologists and historians. For the purpose concerned, we need to compare the lives of the common people in past centuries, and even past millennia, with the lives of people with similar relative status today. Therefore, we must study the relative availability and reliability of sources of food, clothing, fuel, shelter; continuity of productive employment and comparative levels of compensation; quality of medical service and sanitary facilities; means available for transportation, intercommunication, and illumination; freedom from tyranny exerted by the wealthy; evenness of the incidence of taxes; and the even-handedness of the bearing of official justice on poor and rich. Wars, coronations and burials of kings, and obsequies of eminent citizens are interesting incidents which punctuate history, but they reflect little light on the actual living conditions of most citizens during the periods concerned. The kitchen middens of Denmark and the iron workings of Sweden disclose more that is significant to us than the whole sequence of personal exploits of northern kings from the Norsemen to the present time which the historians list.

The last five hundred years have changed the conditions of human life more than all the preceding thousands of years going back through history; and the last century and a half have brought greater changes than the preceding 1000 years. In illustration of the slow progress of the early development of the arts for the use of man we may refer to navigation,—a very old art. The shipwright's art and the use of sails on ships have come down to us

* Published in *Science*, Dec. 29, 1933, Vol. 78, pp. 589–596.

from far antiquity, through the Egyptians, Phoenicians, Chinese and others, but as late as 296 A.D. the orators of the day extolled the consummate bravery of the Roman sailors who, for an invasion of Great Britain, "ventured to set sail on a stormy day and with a side wind." Also, the great naval battle of Lepanto was fought in the last third of the 16th century of our era with most of the warships propelled by oars as well as sails.

We engineers assert categorically that the great changes in the arts which have occurred in the last few centuries as the outcome of scientific research, discovery, and invention have been the foundation for tremendous improvements in comfort, convenience and assurance of life for the common people. There is more to engineering than combinations of structures and machines and their relative money economies. The field of political economy (economics) is invaded. Many of us who were in military service during the World War learned that seconds of time might count more heavily than dollars of money, because seconds under some circumstances measure losses in human lives. In civilian affairs there exists something of that same balancing of human welfare versus money economy, and this has come into general recognition with the recent centuries, though not sufficiently often remembered when plans are made for expending money for engineering projects.

On the other hand, many social reformers stand ready to risk the great gains that have been secured as a consequence of this developing social spirit; and they do so through an egoistic ambition to press forward into action without the proverbially-needed careful "look before you leap." They fail to reflect upon how much may be lost by steps taken over-quickly and they fail to approve (as too slow to satisfy their ambitions) the steadily continued orderly progress which assures safe results.

That gains in comfort and happiness have been made for people in general as a result of engineering progress is sure. Compare the life of the most meagrely-fed and housed of our farm population with the sordid and insecure life of European peasants two hundred years ago * who lived in indescribable misery while they hacked away at the impoverished soil for subsistence! When the usual steps achieved by science and logical reasoning appear too slow, it is well to consider whether the corn farmers of Iowa, the wheat farmers of Kansas, and the cotton farmers of Georgia, when their crops grow irritatingly slowly due to a cold growing season, try to aid the plants by pulling on their stalks.

* For illustrations of state of living for peasants in France about 1800 see Balzac's novel, "Les Chouans," and for Scandinavian peasants see Selma Lagerlöf's "Gösta Berling."

Interruptions caused by Nature in the supply of food, raiment, and shelter are not new phenomena. A Chinese poet, a half-dozen centuries before the Christian era wrote:

> "The people are now in peril;
> They look to heaven, and all
> is dark and dumb."

But we are dealing in this decade with a different category, where there is a human feeling that all should be fed and provided with shelter, but yet hunger and cold are suffered alongside of stores of food and fuel. This problem is not insoluble, but it cannot be solved by philosophical arguments.

In social betterment, it appears that what any generation cries is impossible, a later generation turns around and achieves through the results of scientific discovery and invention; but in every generation, the professional reformer who is ready to justify any means (even if unethical) which accomplishes a good specific end is one to distrust and avoid. Such ones usually also resent criticism, however just, of their projects and thus open themselves to egregious mistakes which later have to be corrected by others. They also overlook the fact that to propose unfair measures for advancing a cause of reform is an injustice to the reform itself. It is true that Time, the revealer of all things, ultimately discloses whether or not a process is real or sham; but in the meantime the mistakes of the reformer cause suffering for the very people that he proposed to aid, unless some sound-thinkers succeed in heading off his egotistical and inadequately considered projects. Many individuals and some committees have to be thus restrained, because their narrow and intolerant attitudes deny to them, as to the apocryphal Troglodytes of the ancients, the possession of the principles of equity or of justice.

Whoever expounds pragmatic political economy correctly must possess an exact and adequate picture of the life about him, and in this use the word "life" means the physical facts and conditions of living as well as the actions and manners of the people, giving emphasis in the latter to the people's conduct as groups. The period of the present is always the time to which a pragmatic political-economy applies; but a knowledge of the flowing development of man's relations to man through recent centuries adds to the liveliness for understanding the economics of today.

Man is not naturally a community animal. His natural unit is the family. Witness the longevity of patriarchal habits among many races, the continuity of tribal relations which characterize the life that has existed indefinitely and still exists in regions inviting to nomadism, and also the maintained strength of family or clan ties in China. The realization of the community tendency is a

child of engineering, as I have pointed out in "The Origins of Engineering"; but the development of that child has, in some respects, been unguided. Having provided opportunity for propinquity, what responsibility have we as engineers to aid in assuring intellectual independence of the human units in the community and in restraining the frictions that grow out of mutual contacts of independent individuals? In joining a community, a man (contrary to Aristotle's philosophic theory) usually does not voluntarily sink his identity in an authoritative state. He usually does essentially undertake to adhere to majority rule even though it may impose conduct contrary to his opinion and his wishes; otherwise, he must get out. But he withholds to himself a privilege and obligation constantly to express his own views, and endeavor by argument to bring the majority into accord with him.

A great difficulty in the situation rests in the prevalence of ignorance, prejudice, and falsehood. "Truth-telling and simplicity are not universal in an advanced political society," and differences of philosophical ethics often cause confusion. The extent to which differences of ethical points of view may go is illustrated by the fate of the American Indians. The irremediable gulf between the ethics of the Indians and the ethics of the white men made conflict to the death inevitable, notwithstanding some individual exceptions.

The current of popular passions is strong and uniform, as Gibbon long since pointed out; and it is likely to be little influenced by logical considerations of precedential material. Galileo wrote "I believe that there is no greater hatred in the world than the hatred which ignorance bears toward knowledge." This would better express the world situation of modern days if it said: the hatred which self-considering and short-sighted ignorance directs against innovation directed in the light of science. We all express approval of the ideal of "the more abundant life,"—but do we all know what we definitely mean by the phrase? We believe in a "fair deal" for all, and I think that we know what we mean by that term; but the "new deal" is a term which is foggy and vacillating. I agree that the description of a corpse does not compose history, for human history is a surging flux of men's blood and its tale must be strong with words of movement and passion; but exactness in the definition and use of terms is as necessary for progress in economics and sociology as it is in the physical sciences.

It is just as futile for an individual to try to remodel nature to his own plans as it would be for a discarded chip of marble to wish itself a part of the wall of a great temple; but a mortal can fit himself to existence in the existing universe so as to secure tranquillity and joy for himself and contribute a proportion of the same for

others. Engineering inventions and preventive medicine have made these things practicable for every one who will suitably exert himself. The changes of physical surroundings which are continuously affecting the manner of human living inevitably require complementary changes to be made in the social organization. The problem is to guide the latter changes so that they shall be truly favorable complements of the favorable physical changes. Professional reformers (where unrestrained) have caused much wreckage by their failure to recognize this limitation.

As already said, we must maintain an objective in this,—which is to bring clear-thinking to bear on these complex topics of economics and sociology as they affect and are affected by engineering activities. From the philosopher's point of view, Art is creative endeavor and all human life is bound up in it. Sculpture, painting, architecture are but higher manifestations of Art as man originated it in prehistory. Scientific research with associated discovery and invention are later originations and have not yet come to be fully identified in their position. This may be partly due to the fact that their æsthetics never have been fully analyzed and people have not realized their relationship to life. When this analysis has been completed we may find more clarity in the situation. In any event, engineers will still affirm that the continuing effect of engineering works on the welfare of society is full of promise for continued human progress. Engineering education must do its part in pointing the way by use of sound thinking in these complex border-line areas, and engineers must fulfill their part in guiding the progression.

5. Relations of Industries to Engineering.—We form clay to make a jar, but the inside space where there is no clay determines the utility of the jar as much as does the clay itself. The engineer who is limited to only conventional processes needs to possess only old conceptions, because his work (whether in design, construction, operation of plant, or business administration) is substantially limited to what has been done before. Such conceptions as the old-time idea of the immutability of matter, the old-time idea of the conservation of energy, and so on, are sufficiently exact for him. But the competent engineering leader needs to have been brought into intimate contact with the latest, shifting thought in physical science and its applications, for the purpose of stirring his imagination while keeping him accurate minded. He needs to have knowledge regarding such conceptions as the intertransformations of matter and energy, the conservation of energy plus matter, energy quanta, conversion of light quanta into electrical energy, and so on; and the manner in which such conceptions have been arrived at out of the old ones, besides securing an intimacy with

those old-time practical ideas. If we do not keep this type of effort in the foreground, our educational processes may prove as futile as Don Quixote's battle with the wine skins.

The wise administration, the continued unfolding of new aspects, the prosperity of the engineering industries are the concern of every individual among all classes of citizens, rich and poor, exalted and lowly, alike. The topic touches the welfare of every individual citizen. Engineering works provide the veins, the nerves, the sparkle and the vital functions which vitalize modern civilization. Agriculture continues to provide the food supply. The government has found it necessary to furnish guidance and support for the functions of higher education and research in the latter. Industry is able to coöperate in the support of these functions applied to the former, and better progress can be made where industry embraces its part in the coöperation and by its achievement illumines the features that economically may be supported by government.

With our abundance of opportunities for new or improved utilization of forces and materials and preventing waste of man-hours and natural resources, the prosperity and influence of the industries are bound up in improving on the old, well-beaten, wasteful paths of practice which have been determined mostly by empiricism. For the supply of men to be relied on in development —the unfolding of new fields and improvements in the old fields —industry has come to rely more and more on the colleges and particularly the engineering colleges. Engineering school men are coming more and more into elevated administrative posts where wise administration must be in command, in addition to carrying on in the designing, manufacturing, and selling branches of industry. Scientist or engineer can become a great merchant if he has the taste and will to do so. The business man who is pure empiricist has proved to be more than 50 per cent failure. Creative intelligence in management and ability in scientific research are two assets for a people that can not be too highly valued. On our success in stimulating them we may confidently rest our future.

As a community, the people of this nation ought to recognize themselves as enjoying a mutual prosperity, security, and happiness such as has not been associated with any other group of 130,000,000 people in history. Why do we not? The answer is twofold: in part (and on account of substantial ignorance of human history), we fail to perceive what we possess; in other part (and on account of inadequate education), we fail to bring to birth many of the advantages that could pertain to our situation. A person becomes wealthy if he produces more than he consumes and sells or otherwise establishes profit from his surplus; he holds his

own if he maintains a strictly balanced budget; and he falls into poverty if he consumes more than he produces and has no means of bridging the deficit. This is very elementary, but it does not seem to be understood by American citizens.

In the same way, if a nation or a state or a locality sends out year by year more in money or products (or both) than it receives in equivalents, it is steadily growing poorer just as would an individual who year after year paid out more than his proper income. Conversely when a nation, state, or locality sends out year after year less than it receives, it is apparently growing richer, and in truth is growing richer provided it is not exhausting some special resource such as the fertility of the soil, the extent of its forests, its oil or ore deposits, and the like. Every nation, state, or naturally-bounded administrative locality ought to make up a balance sheet year by year so as to discover whether (as a community) it is growing richer or poorer as a consequence of trade. This is as important for each such community as for an industrial or commercial organization.

The effects of engineering activity on the conditions of living for the generality of people are the opposite from the results often alleged. The advantages of comfort, convenience, and assurance of life I have already spoken of. The levels of wages and cost of living are worthy of examination. Mr. Philip Snowden, the well-known British socialist, whose ability and honesty of purpose are established beyond cavil, points out in his book, Socialism and Syndicalism, that wages in England had risen 78 per cent during the half-century preceding the year 1900 while the prices of goods had tended downward.

Fourteen years later the World War opened and comparative relations have been disturbed ever since, so that it is not competent at present to make later comparisons of the same nature. However, as a straw to indicate the direction of the wind in fields where financial disturbances have not been too great to allow engineering betterments to exert their effects, I will call your attention to prices for kilowatt hours in recent years. It is estimated that the average revenue of private electric light and power companies in the United States was 6.03 cents per kilowatt hour sold by them in the year 1930, 5.78 cents in 1931, 5.53 cents in 1932, and 5.49 cents in 1933. This is a decline in the price of nearly three per cent per year on the average, and the price continues to fall. Here we have a startling contrast to the rapid rate of increase of taxes (federal, state, county, municipal, and special) in the same period; and taxes are still rising in general.

You can glimpse from this contrast some inkling of reason for the apprehension of clear-thinking citizens regarding the extent to

which costs may be taxed on the public if public (government) ownership and operation of public utilities and other businesses are extended. Political instability in our local and state governments and the uncertain tenure of employment for their employes militate against efficient service. So little (if anything) is to be gained under the most favorable conditions by public ownership of such properties as the public utilities that unstable management will wipe it all out and leave a deficit to be borne by the taxpayers. Mr. Edison is reported to have trenchantly remarked regarding government-operated business that "there is far more danger in public monopoly than there is in private monopoly, for when government goes into business it can always shift its losses to the taxpayers."

Much sensational discussion has occurred which relates to the distribution of wealth among various classes of citizens and special sympathy is usually expressed for farmers. The sympathy is deserved, because in ordinary circumstances farmers are forced against their desire to be gambling constantly on the weather; but recent carefully collated statistics show that the distribution of wealth amongst the farmers does not differ so very much, as a class, from other American citizens as a class. Of course, the aggregate of wealth among the farmers is less. Perhaps some of the loose-thinking about these things is due to disparities in rates of growth of various citizenship relations. In the eighty years from 1850 to 1930 the population of the United States multiplied about five and a half times, rural population multiplied about three times, national wealth multiplied perhaps ten times, value of farm lands multiplied about fourteen and a half times, railroad mileage multiplied about twenty-five times, and the value of manufactured products produced per year multiplied more than seventy times. The fatness of the last figure is partly an aftermath of the World War, but nevertheless it is plain that engineering activities have grown very fast. This has made them shining objects for attack as producers of disparity in the distribution of wealth, which attacks are made by sentimentalists and self-seekers.

The social sentimentalists have flung a bridge of fancy across to a promised land of no-poverty into which we would all like this nation to march. But a bridge of dreams built on foundations of flimsy hypothesis is not one on which to risk the safety of the moral and material welfare of this nation. A crash would sacrifice the great gains which have been secured for humanity by means of scientific discovery and invention during past generations and the loss would fall heaviest on the people who now possess little substance. The sentimental objective is good, but our advance must

be cautious instead of heedless and must be made along a solid path built with engineering care on foundations of observed fact.

Another difficulty with the proposals of our professional economic and social reformers is that they wish to impose on every citizen a regime of doing what the reformers imagine he ought to do and of doing it in a way that they imagine it ought to be done; but most of us, who compose our great population, wish freedom to choose our own careers and to carry on in our own ways, with only such restraint from government as is sufficient to prevent us from imposing on our fellow citizens. We are not willing to admit the validity of a procedure because some one thinks it may be useful. We insist that, if adopted, it shall also provide us with freedom and fair play. If we are to maintain our sensible wishes in the face of the active efforts of sentimentalists, the state of our government emphasizes to us the truth of John Hay's remark that "Freedom is an angel whose blessing is gained by wrestling."

Since the basis of the formal economics now applied to commercial and industrial life was set up many revolutionary influences have been brought into social organization. The following enumerated eight seem to me particularly significant:

1. General adoption of manhood (or universal) suffrage and establishment of "representative" government. This brings an influence of the general population to bear on government and imposes a requirement for coöperation between elected representatives and the "multitude."

2. Formal government programs set up for the general good, "of the people, by the people, for the people," which condition extends the scope of needed coöperation to the mutual relations of all members of the population.

3. Universal free education established by the public with the purpose of producing a competent electorate, but with innumerable chances of inadequacy.

4. Business expansion and adoption of the factory system after the opening of the era of invention, associated with rapidly expanded use of money (coin or currency) in trading, the establishment of credit-money as a widely used instrumentality of business, and the decline of barter to substantial extinction. Here again, coöperation becomes a prominent need.

5. Development of the limited-liability, corporate form of organization as a major and general instrumentality of business in contra-distinction from business carried on solely by individuals or small groups of individuals joined together as partners; still more strongly emphasizing need for coöperation as distinguished from individual acts.

6. Organic expansion of scientific discovery and invention, out of which have grown preventive medicine, sanitation, modified agricultural production and processing of agricultural products, expanded industrial production, reliable transportation, etc. The need for coöperation grows insistent. For example, sanitary conditions in a city would not exist if measures were not laid down so that all citizens coöperated by observing the primary sanitary requirements.

7. Development of convenient and speedy transportation and quick intercommunication of intelligence. This enlarges the opportunities for business and social relations between persons and between populations of districts. It also improves the opportunities for contacts which may be utilized for bettering conditions of coöperation.

8. Improved processes for artificial illumination, which further increases the possibilities of productivity and of social relations.

Along with these influential features, which have arisen since the birth of the grandfathers of some of us and which have been thrown into the social situation by the intellectual activities of innumerable very able men, there has become a tendency to overcome faults of social organization by the introduction of hastily formulated legislation, restrictive of or controlling over industry and agriculture, designed ostensibly to safeguard public interest and of necessity having a political slant to reflect the views of large voting groups. Some of this legislation has been wise. Some of it, though well intended, has not been well considered in reference to its major repercussions and its subsidiary effects. Some of it has been definitely vicious in its implications and results. The questions surrounding technical developments and the most effective application of science to human welfare are closely bound up in some of the legislation. At the present time we are failing to handle such questions effectually and with proper foresight.

Of the foregoing eight numbered features, Nos. 6, 7, 8, and also 4 in respect to the factory system, have grown essentially out of pure science and engineering. The numerous practitioners of engineering in their professional life in the industries and in general business are well established for maintaining these activities. The desirability of these activities has come to be generally appreciated. Within their scope, the engineers coöperate closely with pure scientists, the latter dealing with theoretical considerations and the discovery of fundamental relations, while the engineers look to the serviceable applications of the science. The coöperation has worked so well in connection with the physical sciences that it is undeniably demonstrated to be of advantage to progress both in the

theoretical and in the applied sciences, and analogy leads to the belief that like coöperation between the engineers and the economists in the faculties of the engineering schools would also produce improved results.

Here is a vitally important objective in engineering education which engineering faculties have as yet substantially failed to bring into the focus. The succeeding arguments contained in Part 6 supplement the foregoing.

6. Engineering Education and Economics Instruction.—Human affairs proceed fortuitously because of superstition, prejudice, and ignorance. Eliminate those three features of human life by means of downright education and the world of humanity would move more uniformly in its orbit. We commonly forget that we cannot successfully forecast the qualities of the future without first familiarizing ourselves with the river of knowledge that reaches into our time from the past and tracing its course through the historical past even to its springing sources; and then we may establish our forecast of future trends as an extension modified out of the joint fabric of the past and present.

Classical scholars have lost influence in this age of scientific discovery and invention because, wrapped up in sole contemplation of accepted artistry, they usually are not apostles of factual evidence. Engineers can appreciate philosophy as a pleasurable trimming, but cannot accept it as a component member of the central structure of engineering education. As an old proverb says, "Ice and embers cannot lie in the same bowl." We have the problem of maintaining intellectual emancipation from the cramping deference to authority and at the same time securing that spirit of coöperation with other educations which is a manifestation of discipline of the mind and of far-sighted generosity of spirit.

The primary facts of nature that have been identified and subjected to measurements are few in number. Most of what we call facts are either inferences or measured relationships, and this situation affords large scope for applying the imagination in engineering as well as in medicine, economics, and sociology. Imagination is the grammar of engineering education, which distinguishes it from artisanship, whether in mathematical or in experimental enquiry. The eye of a sound imagination pictures things-that-may-be with the same clearness as the hairs of the brows and head may be seen in a mirror. A fault with the economists and sociologists is allowing imagination to travel unbridled and in paths unassociated with the practicable realities of human existence at the time concerned. Mr. Henry A. Wallace illustrated this excellently in the following sentences: "We did not get far with the treatment of malaria as long as we believed in the theory that disease was

caused by evil spirits and the way to get rid of disease was to scare out the spirits. Real progress came only when we used quinine and got rid of mosquitos. In approaching economic problems most of us are still in the old witch-doctor days." There is the hinge on which this part of my argument turns. However exactly we deal with our physical problems, in our human relations we commonly neglect exact reasoning and rest our conclusions on a bundle of prejudices which themselves have grown out of a lot of incompletely digested and more or less inaccurate comparative data.

Discussions of sociologists center too largely on the disparity between our rich and our poor in money, and too little on the richness of our possibilities for distribution of goods and our poverty of performance, together with ideas for improving the means for distribution. Perhaps they would be justified in saying that the latter topics belong to the engineers, who thus far have acted on the details only. It is my opinion that concentration on discussion of these topics would soon bring improvements to pass.

As long as our sociologists remain emotion sentimentalists, so long will social progress in America lag. The engineers cannot cooperate effectually with them until they get (and keep) their feet on the ground. By the word sentimentalists I here mean people who plan social experiments by wishful thinking, without experience to foresee the pitfalls into which the experiments may lead; and who avoid undertaking the dogged efforts required to secure the experienced perspective needed to establish judgment and foresight. Much of the usual arguments regarding community economics and government are as inconsequent as the conversation between a horse dealer and his friend: Said the dealer to the friend, " Had I known that Smith would fail to pay me for that horse he bought, I should have charged him $50.00 more so as to get more profit." To this the friend responded that " The charge ought to have been $50.00 less so that your loss would have been smaller."

The American slogan, "Life, liberty and the pursuit of happiness" is honest and sound only when the "multitude " are guided on the material side by sound economic principles, which principles are put on a level of mental equality with sound sentiment and sound morals. Sound economics calls for coöperation, and cooperation leaves the individual in freedom except for restraint needed to prevent oppression of his fellows. Communism sinks the individual into the commonality and freedom ceases. Fascism demands yielding to the dominant state, and again individual freedom ceases.

"There is convincing evidence," says Philip Cabot,* "that in this country men in the professional and administrative classes

* "Industry and Government," *Atlantic Monthly*, December, 1934.

have not been properly educated for the work which is now required of them. On the principle that 'he who has broken the head must find the plaster' our educational system should step into the breach. We are said to be suffering from overproduction. If this is true, the remedy is not to limit production and destroy the abundance which plagues us, but to teach men how to use it. Clearly this is a problem of education, and on our ability to divert a part of the immense surplus energy of the nation into this field the future of our civilization may well depend." To this he happily might have added that, aside from the specific problems of production of agriculture and its related activities, the questions he refers to affect the field of engineering and many of them are component parts of our field. Can we allow this challenge to rest unheeded?

Considering engineering education in general in this country, we now give too exclusive attention to the technique of existing engineering practice, and correspondingly too little to the underlying science and the imagination that will guide the improvement of the practice and also too little to the pragmatic economics the observation of which makes engineering practice most adequate and useful. It is appropriate to consider whether a proportion of the engineering schools should direct their attention particularly to extending their activity into the latter features while the major number maintain the present and well-established route, or whether all ought gradually to increase emphasis on the latter features.

We must not belittle or lessen our treatment of engineering techniques for the sake of the new trend. Also, in directing our attention toward the economics affected by engineering, we must not belittle or dilute the increasing effort to understand and utilize all physical science in our work. The new emphasis must be added alongside of and made collateral to the old, while we are still farther strengthening our coöperation with the pure scientists. Every new engineering activity was started in a small way. We can start this idea of improved economics coöperation in a small way in every engineering school and fertilize it for growth. This would bring us, under modern conditions, to an association of engineering science and technique with pragmatic economics more nearly corresponding with conditions when engineering schools were new and which has been lost during the past half-century under the weight of accumulating engineering techniques and growing complexity of social relations. At the same time, certain of the larger engineering schools should enter upon this project in an extensive way and thus serve as guides for farther advancements which may become desirable.

7. Qualities Needed in the Teaching Personnel.—Defining the general objectives of engineering education belongs to the field of this Society, and the Society has played an important part; but defining the particular educational objectives of any engineering school and charting the direction of progress in that school are duties that should be performed by the leading personnel of that institution. The richness of character which in this field is essential for complete success of the teaching personnel cannot be secured if the duty of defining objectives is assumed by administrative officers of the colleges. In spite of the ups and downs of faculty arguments, I am of the opinion that the process of devising and guiding educational policy in any institution of higher learning is a faculty responsibility and that both faculty and administrative officers should insist upon it being maintained securely in that quarter. Otherwise the members of the teaching staff drift into a state of being "hired men" and their work ultimately becomes mostly conventional as far as educational processes are concerned.

It seems to me that there must be something of the mystic and perhaps of the prophet in a man's soul (however realistic and exacting he may seem to his associates) if he is to serve as a great influence in education. Each of my very slight contacts with Charles W. Eliot gave me the feeling that somewhere in him resided those qualities. It seemed to me that they also were possessed by Richard C. Maclaurin, whose untimely death prevented him from proving the soundness of his dreams of a vital human education. Charles R. Van Hise possessed the qualities. It is true that all of these examples were college presidents but they previously were faculty members for long periods before their presidencies, and developed their ideals as such.

The life of an influentially successful teacher is one of constant concentration and toilful industry. It cannot be traversed on the wings of wishful convenience and idle inclination. This condition holds with particular force in the realm of engineering education because the powers and interest of the individual in research and exposition must be accompanied by a professional attitude toward the useful applications of physical or biological science and mathematics. An engineering teacher belongs to engineering first and then to education. That is, each David in our branch of education must possess a scholarly understanding of the needs of engineering and its promise of service to civilization before he can succeed in slaying (by a pebble from his sling) the Goliath of educational conventionalism. Fertile originality will lead him to try different methods of exposition in his teaching; but his work is fundamentally related with natural science and social science, and the investigations of himself and his students should be directed to

those. However, engineering teachers may well read somewhat of the lives and methods of great teachers in other fields, thereby deriving inspiration and encouragement for reflection.

Generally speaking, the engineering schools of this country receive their students from the most ambitious and well-prepared graduates of the high schools. Nearly two-thirds of the fostering students have been scholastically in the top third of their classes, and only a very small proportion come from the bottom third. Therefore the entering students rank high in both scholastic standing and ambition when they come to us. Nevertheless some professors view their students as " dubs " who possess as little of brains as an empty casserole! Is it any wonder that such professors, by the time that they discover some brains in their students, also find that the brains are cooked?

Many difficulties of engineering teachers arise from incomplete coöperation afforded by teachers of mathematics, mechanics, physics, and the like. Research in pure mathematics consists in seeking out new forms of functions and equations and new processes for solving equations. In this occupation the problem of interpreting the meanings of terms into their physical significations is without much import. Carrying on such mathematics is not an engineering job, though its prosecution is very important to engineering because it brings tools to the engineer which he may utilize in his work. A mathematician who is not interested in interpretations (that is, one who is not interested in the application of mathematics as a tool of reasoning for definite physical situations under enquiry), should never be allowed to attempt the teaching of mathematics to engineering students; because his efforts are likely to develop in such students a strain of contempt for mathematics instead of administration for a powerful and improving tool of which each student should secure possession.

There remain large opportunities for the exertion of initiative and courage in guiding engineering education. Elimination of the conventional, encouragement of independent-mindedness associated with exact thinking, elimination of flabby-mindedness and superficial thinking are all operations which require intellectual courage for their performance. Without these reforms we can add no power to the improvements of economic thought which should be aroused on account of the influence of engineering activities on society. In these things, as in others, there may be "a bright wreath for the brows of the brave," but usually there is criticism and reluctance of appreciation which impose notably heavy tests on the mental courage required for performance. World experience has unceasingly demonstrated that physical courage is more plentiful than are brains accompanied by mental courage. It is easier

also to stimulate physical courage to its peak than it is to stimulate mental courage to the peak of its endeavors. The men of leading qualities for engineering education therefore are not over numerous notwithstanding the opportunities available.

In spite of the difficulty of securing men, each of whom jointly possesses a mastery of his topic in engineering, the research spirit, pleasure in accurate exposition and a sympathetic imagination (which possessions are needed in the composition of a competent teacher of engineering), the man who entertains the impression that he is the only one who can successfully do the things of the world which relate to the field in which his career is cast, is fooling himself. Formerly those who had proved themselves incompetent at other occupations thought themselves competent to teach, but experience has proved the invalidity of this idea. Nowadays we consider competent to teach in engineering only those who would be highly competent in any other professional or scientific occupation that secured their whole interest. Those who do not become teachers in permanence may become leaders in thought and in practice, to achieve which substantially the same qualities of mind are requisite. On the other hand as Plutarch says, "He who busies himself in mean occupations produces, in the very pains he takes about things of little or no use, an evidence against himself of his negligence and indisposition toward what is really good." The universe of knowledge continues to expand in spite of the depression, and an acquisitive desire for competition exists in the mind of any man of lively and honest ambition. "Exclusiveness is inevitably followed by barrenness," as was remarked by John Hay.

The man is always somewhat lonesome whose reflections carry him beyond the intellectual timber line of the multitude, because he has relatively few neighbors in thought. His attitude is not understood by the mass of people, and his views become acceptable only after many repetitions and long delays. However, the lonesomeness can be softened by the forward man himself allowing the roots of his intellectual activity to draw sustenance and inspiration from ground below him but toward which the multitude is aspiring. This gives some touch of sympathy between them. Humphry Davy and Michael Faraday (to name only two out of many of notable distinction) had this quality, as is shown by the popular success of their science lectures, which lectures were built out of their own great mastery of their individual branches of learning.

The one-time cry of fear over what was called "narrowness" or "specialization" in the engineering curricula was scotched by the reports of the Board of Investigation and Coördination and its committees of engineering faculties. Our curricula are good, and we modify them year by year as experience shows that modifica-

tion is desirable. Their variety is not greater than the spread of tastes of our most competent students. We need expansion by adding collateral curricula emphasizing the economic and social influences of engineering activities, but there is no ground for denying the broad educational value of the existing curricula. It is not greater breadth in individual curricula that is the need, but it is rich and scholarly intellectuality of each member of the teaching staff which is needed in order that students may be under proper influences. Such intellectuality includes a critical appreciation of the serviceability to civilization of the engineering activities and the romance associated with their development, in addition to true mastery of a particular technical branch.

The greater breadth in engineering education which has been much discussed heretofore can be achieved only by insisting that each member of an engineering college staff shall develop himself in breadth by individual reading and reflection, while insistently maintaining depth of mastery in some aspect of engineering. With this result achieved, the objectives hereinbefore outlined will be kept assuredly in focus and progress be made toward the goals.

APPENDIX

Reliability—Dependability, trustworthiness.
Sincerity—Honesty of purpose, genuineness.
Coöperation—Willingness to help and coöperate with others.
Patience—Sympathetic attitude toward slower minds.
Tolerance—Forbearance with reference to advice, opinions, or actions with which one is not fully in sympathy.
Tact—Discernment of what is appropriate to do or say in dealing with others.
Self-control—Emotional stability, control of temper.
Mental courage—Ability to pursue a course deemed right in face of objections or disapproval.
Self-reliance—Confidence in one's self, one's judgment and opinions.
Industry—Application to work, diligence, perseverance.
Resourcefulness—Ability to choose suitable means for carrying work through.
Accuracy—Precision, exactness, especially in statement of facts.
Tenacity—Steadiness of purpose in "carrying through."
Sense of responsibility—Inherent recognition of relative fitness of any situation.
Native ability—Intellectual capacity.
Quickness of apprehension—Ability to recognize relations of things and thus appreciate the meaning of instructions.

Spirit of enquiry—Tendency to examine closely into the meaning of observed things.
Analytical ability—Ability to analyze a situation and reduce it to its simple elements.
Resourcefulness—Ability to choose correctly between various courses of procedure.
Imagination—Mental synthesis of new ideas from elements experienced separately.
Originality—Capacity to go on one's own reasoning and intuition.
Initiative—Taking the lead on one's own responsibility.
Judgment—The power of arriving at a wise decision or conclusion on the basis of indication and probabilities.
General knowledge—Clear perception of conditions outside of immediate field of training.
Technical knowledge—Understanding of field of specialized training.
Clarity of expression—Ability to express one's self clearly.
Personality—Attractiveness of manner.
Neatness of person and dress.

SOCIAL SCIENCES IN ENGINEERING SCHOOLS

By WILLARD E. HOTCHKISS

President, Armour Institute of Technology

When this society invited me to read a paper at the annual meeting in Chicago two years ago, appreciating your courtesy to a neophite in your midst, it seemed appropriate to speak somewhat as an outsider looking in. "Engineering as an Approach to Culture" was a subject which enabled me to do this, and at the same time to refer to the cultural implications of engineering from the background of my work in another field.

Today, one of the premises from which I shall proceed is that just as engineering is an essential element in culture, so culture is essential in engineering. But in making culture again a point of departure for my discussion, I do not wish to give it undue emphasis nor to attribute cultural values to the social sciences essentially different from those which are latent in numerous other subjects in engineering curricula. The case for the social sciences as I see it must rest upon their potential contribution toward a result which is jointly cultural and professional; so within the scope of my subject, I shall try to integrate culture with the discipline for professional competence, which it is the task of engineering education to advance.

At the risk of expounding the obvious, I should like to indicate what I have in mind when I speak of culture as an element in this composite educational objective. Culture, in this connection, suggests to me preparation for a rich and many-sided life; it suggests awareness of the world about, intellectual curiosity and capacity for reflective thought. Culture connotes understanding, poise and discrimination in weighing ideas; it signifies perspective and a sense of proportion in appraising personalities and achievements. Lastly, culture implies sensitivity to ethical and esthetic values.

To say that engineering education, along with all education, attempts to develop these qualities, is to repeat a truism; but, obviously, that is not the whole story. These subjective essentials of culture are normally associated with action. Contemplation and action at their best are interwoven, and it is through action that contemplation becomes fruitful. In this light culture is not a mere decoration, but an integral element in professional competence.

Our architectural colleagues express a somewhat similar idea when they say that form follows function. But whether we say

that form follows function, or that culture and competence are but two sides of the same shield, our alliterations bring us to about the same point. In essence, we are declaring a union of objective and subjective aims. We are saying that the test of excellence for courses of study and for organization and presentation of material is the function performed in producing a desired result; we are laying out courses in conformity with a unified purpose in which cultural and professional aims are measurably integrated.

Concepts similar to these find frequent expression in the literature of this society. Moreover, there seems to be general agreement among engineering educators that a modicum of work in the social sciences is essential in engineering curricula. Students likewise usually assume that it is a good thing to broaden their outlook, and are at least tolerant to the notion that the social sciences will contribute to that result. When, however, we try to set forth the objectives of social science teaching more definitely, or consider what subject matter to include or how to present it, the area of agreement becomes greatly narrowed. Members of faculties are frequently not very sure just what the social sciences are expected to do for students, and the student's attitude toward particular courses in many cases is indifferent or critical.

While the social sciences are in no sense unique in calling forth student criticism, the case is not quite the same as it is with such subjects as drawing, mathematics and science. Engineering students know that they need drawing; they know that they need mathematics, however ceremoniously some of them may burn their text books after examinations; they know that they need laboratory science; and recognition of the need for English is now well nigh universal. Social science, I believe, is on the way to similar recognition, but its objectives are still indefinite, and questions pertaining to the amount, selection, organization, and presentation of materials are still highly debatable.

Possibly it will help to clarify this debate, to subject the social science part of engineering curricula to appropriate tests of fitness. Among numerous tests which might be applied I shall suggest six, which are somewhat interrelated but sufficiently distinct to serve as guides. Stated in the form of questions, these tests are:

1. Is the material relevant to an engineering education?
2. Can it be used to stimulate intellectual curiosity?
3. Does it give opportunity for discipline in accurate reasoning?
4. Does it include subject matter concerning which definite action is contemplated as a result of study and analysis?
5. Does it challenge instinct of workmanship?
6. Is it sufficiently flexible to give scope to varying capacities and interests of individual students?

Before enlarging upon these tests, it is perhaps in order to indicate why discussion is addressed to the broad subject "social sciences" instead of the narrower one, "economics." There are two reasons for this. In the first place, I should like to avoid some of the implications which have attached to traditional economics courses in the past. Reference will be made to these later. In the second place, it seems desirable to postpone discussion of individual courses until the suggested tests for selecting, organizing, and presenting subject matter have been considered.

Taking the tests in order, I am inclined to think that relevancy is not only first on the list, but first in importance. However, the problem of relevancy is not primarily one of finding relevant material, but of assembling it and making it available in such a form that its pertinence to an engineering education becomes at once apparent to the student. The more closely teachers of social science are able to identify themselves with the realities of engineering enterprises the more successful they are likely to be in solving this problem.

Approach to a solution is found in the fact that back of every engineering project is a human situation. Engineers design and construct projects because some one thinks they will satisfy a human need which will give rise to a demand for the products. The extent to which these assumptions are correct determines the validity of the project. Engineering activities are inescapably dominated by economic and social factors. Similarly human values enter at every stage and in respect to nearly every item involved in securing materials and equipment, and in recruiting and directing the men who carry on engineering enterprises.

Successful engineers today, in many cases, are influencing the social aspects of engineering and industrial enterprises as completely as they are the technical aspects. In many other cases engineers are called in council when decisions with far-reaching social implications are being made. Even purely designing engineers cannot advance very far without having considerable responsibility for handling men, an obviously social activity. The most casual reading of the daily press will indicate how increasingly sensitive and important many of these human adjustments are becoming. It is just as essential that engineers know what they are doing and why, when they deal with these social and economic questions as when they consider the technical side of their work.

The fact that engineers in the past have tended to isolate the physical bases upon which their projects rest and deal with the measurable and finite forces and values embodied in them, does not make these measurable and finite forces and values in any sense the exclusively important factors with which engineering

and engineers are concerned. There is ample evidence that shying away from the human factors in engineering places a limit upon success, both financial and emotional, which engineers are able to secure as a result of their work.

Since these are obvious facts which involve jointly engineering and social science, the more use we make of them in introducing engineering students to social science the easier should be the task of making work in this field appear pertinent and important. Work that appears relevant to the teacher may not appear so to the student. The indifferent or critical attitude to which I referred earlier in the paper may easily result from failure on the part of the student to recognize that subject matter presented in a social science course has any significance for an engineer. But whatever their bases, such attitudes easily grow into adverse traditions which have to be overcome before work in the social sciences commands acceptance on the part of students comparable to that given to the more directly engineering phases of the curriculum.

The first step leading toward successful teaching of the social sciences, as I see it, is to build up student acceptance for courses in this field. To this end, it appears highly desirable to begin the work in the freshman year before prejudices have had opportunity to crystalize. This brings us to the question, what kind of social science material freshmen are prepared to take. Recent publicity about examinations which high school seniors are expected to pass tends to increase our respect for the knowledge which college freshmen bring to their work. Starting with what the individual freshman knows, what he is able to do with his mind, and with his interests and enthusiasms, including his desire for an engineering education, the question in social science, as in all subjects, is how to build up these foundations.

In general, freshman students are more likely to be interested in concrete problems than in abstract principles. The problem approach greatly simplifies the task of selecting material which the freshman student will recognize as relevant. However, relevancy is only one of the conditions to be met. If a problem appears relevant, that fact alone will go far toward stimulating an initial curiosity which will incline the student to pry into it. But he cannot follow his intellectual curiosity very far if material for study is beyond his reach or is available only at an unreasonable expense of time and energy. Accessibility of material is a primary consideration in any problem approach to teaching.

Simplicity is another obvious requirement at the start. A problem need not be easy to solve, but it must be manageable. If it ramifies into hopeless complexities before the student comes to grips with it, its educational value for most students will be lost.

If manageable problems which stimulate intellectual curiosity are presented, it is no insuperable task so to direct study of them as to provide discipline in accurate reasoning—the third of my suggested tests.

But mere reasoning about problems, however relevant and however much they arouse curiosity and stimulate thought, is not enough. Thinking is not exclusively a matter of discipline; it is a means to an end, and the end sought is a sound solution of some problem. It is the quest of such solutions that transforms problems from copy-book exercises into realities.

This realistic test of discovering bases of action is not an easy one to meet. The very fact, however, that it is difficult even for adults who are well trained in their particular branches of social science, to recommend fitting capstones of action, and the further fact that many persons who lack such training and who are without any adequate background for reaching conclusions are frequently prolific with insistent suggestions for action, make it all the more essential that in our educational effort, thought and bases of action should develop side by side.

I trust that I have carried discussion far enough to indicate what I mean by the first four of the six tests proposed for appraising social science materials. These tests, it will be recalled, are relevancy, stimulation of intellectual curiosity, discipline in accurate reasoning, and finally a conclusion embodying a basis for action.

Considering my fifth test, appeal to instinct of workmanship, possibly I may seem here to suggest encroachment upon the field of the shop and the laboratory. Should such suggestion arise, my response would be that instinct of workmanship which is confined to the design and construction of physical objects and to the operation of machines and equipment, however perfectly developed, is incomplete and lop-sided. The same regard for form, proportion, perspective, and for skill, which rules the drawing room, is equally essential in other phases of an engineer's education. Witness the inability of many engineers to write good English, or to make an effective presentation in words on even a purely engineering subject. Channelling the student's instinct of workmanship into such lines as organizing materials, formulating balanced statements of problems, devising and testing possible solutions, and preparing and presenting reports, plays an indispensable part in education, whether viewed from the standpoint of culture or of competence. Social science study offers ample occasion for stimulating and developing instinct of workmanship in this field to parallel that developed in other fields.

This brings us to the last of the suggested tests, flexibility to meet the varying aptitudes of students. This test will doubtless

increase the amount of work teachers will have to do in selecting, preparing and assigning problems, but I doubt if any work they do is likely to be more fruitful. The problem approach to the work of the freshman year will make it feasible to apply this test much more effectively I believe than could be done with any of the possible alternative approaches.

Among other reasons for adapting problem material to the varying aptitudes of students is the selective service which a freshman course in social science can render in differentiating those students who appear to have an executive bent from those whose aims focus primarily on design and engineering technique. The man with a pronounced technical bent will probably be content if he secures a very mild orientation in social science, and it is doubtful whether much more than that should be forced upon him, but that would be far too narrow a standard for the group as a whole.

In setting up these somewhat dogmatic requirements, I am well aware of the difficulties to be overcome. The chief difficulty, I believe, is in finding problems that are sufficiently simple so that the danger of wandering off into inscrutable complexities can be avoided. It is desirable also to have some logical relationships between problems, so that one problem will lead naturally to another.

Questions as to what subjects should come first, how many fields of social science should be included in the course of study, what part of the work should be required of all students; how, if at all, differentiation should be made among the several engineering options; how much purely elective work should be available in engineering curricula—these, and other questions of policy, obviously do not require uniform solutions. When once social science work is set up in any program in pursuance of definite educational aims, suitable answers to these and similar questions will, I believe, follow naturally from the conditions which surround the particular school.

Any one who has noticed the labels attached to the social science courses introduced at Armour during the past two years will recognize, perhaps, that they conform in the main with the educational philosophy here outlined. In naming our courses we are giving ourselves wide latitude as to their content. The titles, Business and Engineering Problems, for the first semester, and Social and Engineering problems for the second semester of the freshman year, obviously enable us to include in the course of study almost anything that either judgment or expediency may recommend as being of service to our main purpose.

We believe that we have a general sense of direction and we are sure our territory is traversed by many alternative routes. Our destination is not any pre-determined fixed point, but we do aim to focus attention on major objectives.

For the purpose of arousing interest at the start and of giving students a grasp of subject matter which will be valuable in their later work, problems which lead quickly into questions of corporate structure and accounting appear to be about the most manageable for beginners. But balance sheets and other business mechanisms are only means to an end. As the course proceeds, students are expected to be more and more concerned with significant subject matter to which these mechanisms apply and to understand the meaning of business principles and procedures which engineers have to observe in carrying on their enterprises. In the main, success with this kind of a course depends upon arousing interest at the start and stimulating intellectual curiosity concerning the business problems which become the subject of study. The key to success, as I see it, lies less in the mastery of a particular range of subject matter than it does in developing an alert and as far as possible a scientific attitude of mind toward whatever subject matter is studied.

The second semester course, Social and Engineering Problems, is weighted somewhat heavier than that of the first semester, on the cultural side, but not so heavily, we trust, as to obscure its professional value. Taking account of the mental growth of students the general plan of the course is similar to that followed in the first semester. We have tried, with some success, to select our problem material from various public engineering services in Chicago, Cook County, the Sanitary District, and the State of Illinois. In spite of obvious difficulties, distinct progress has been made.

In addition to the work of the freshman year which carries a total credit of seven semester hours, we are requiring a total of eight semester hours in the senior year, divided equally between courses which we call respectively, Business Policy, and Public Policy. It has been assumed that during the sophomore and junior years students will have retained some interest in social science subjects and will have matured in their own observations along those lines.

Since we have not yet had a group of senior students who have taken the work now offered to freshmen, and since the freshman work is undergoing the change incident to an experimental course, it is too early to reach definite conclusions either as to final results or as to changes in organization which may become desirable. Possibly the gap between the freshman and senior years is too great. However, we believe that the two closely related subjects, Business Policy and Public Policy, are well adapted for senior problem courses. Remembering always that our set-up is frankly experimental, the response from our students is reassuring.

Earlier in the paper the fact was stressed that discussion would have to do with the social sciences rather than with the more restricted subject of economics, and mention was made of certain implications which in the past have attached to traditional courses in general economics. As far as I can ascertain, economics courses have not been especially successful in colleges of engineering. In reporting to my Board of Trustees last October, I referred to enlargement of work in social science at Armour, and concluded with this sentence: "After a careful survey of results in numerous engineering schools, the traditional course in general economics has been omitted."

Traditional economics, especially as a first course for engineering students, has several disadvantages. In the first place it is extremely difficult to make a large part of its subject matter appear pertinent to either the professional or the cultural needs of an engineer. Moreover, to the extent that economics employs deductive reasoning with but meager opportunity for testing hypotheses objectively and without bias, it is likely to impress students as highly speculative. The position in which economics teachers sometimes find themselves of forcing factual material into conformity with accepted theory, and the highly controversial character of much of the discussion do violence to mental processes which in other parts of their work engineering students are taught to regard as indispensable to sound thinking.

It is just as essential to use known facts to test the validity of preliminary hypotheses in social science as it is in mathematics and laboratory science. Such testing is frequently difficult, but this merely means that introductory material should be carefully selected so as to enlarge the feasibility of such tests. Sound scientific methods are as indispensable in the social sciences as in other subjects.

In seeming to discount the speculative element in traditional economics, I am not implying that all social science teaching should be corralled within the confines of demonstrable fact. However, except for students whose aptitudes lie in that direction, abstruse theory is likely to alienate potential interest and thus retard the type of mental development which it is the purpose of economic study to advance. Aside from the potential professional value of social science, the engineer presumably desires to understand the functioning of the world which his science and his technique have done so much to create. Like all educated men, he is interested in the many question marks of our present civilization.

In pursuing this interest the discipline to be secured in reasoning from contingent data is probably one of the greatest values

which the social sciences can contribute to engineering education and engineering competence. To this end, study should be as far as possible directed from data toward conclusion, rather than in the reverse direction. It is essential too, to restrict the factor of contingency within the narrowest practicable limits, just as all business and engineering enterprises have to do in actual practice.

In a recent radio address, President Hutchins of the University of Chicago, referred to the fact that for the past forty years universities " have been endeavoring to create social sciences, which if they can be created, may prove as beneficent to mankind as natural science and the technology which rests upon it."

If engineering students can think of social sciences as in the process of creation and occupying a place similar to that of the physical sciences in past generations, it may help them to see that social study is not a foreign substance in engineering education. In any case, we should try not to alienate at the start the potential interest which the engineering student is likely to have instinctively for material which he can incorporate as an integral part of his preparation for an engineering career.

Though cause and effect may be more obscure in the social sciences today than they are in mathematics and in physics, it is one of the major tasks of study in this field to clarify these relations. Progress similar to that which was previously made in physical science is now being made in various branches of social science in proceeding objectively from the known to the unknown. The fact that data are complex is an added reason why engineering students should expand and adapt methods of reasoning which have earned their respect in physical science and engineering. If we permit the inference that in entering the realm of social science the student passes from a sovereignty of scientific law to one of speculative contemplation, we are sacrificing, perhaps, the greatest advantage we can have in teaching social science to engineers. Still worse, we depart from actual human experience.

Even though at times social science may demand a type of thinking different from that which the engineer employs in mathematics and in physics, that fact does not alter the basic laws of logic. Social science is a vehicle for carrying along side by side in unison varying methods of reasoning which are merely different aspects of integrated intellectual growth. The engineer has constantly to consider how far man has to conform to conditions set by physical forces and how far these forces can be made to conform to the purposes of man.

One expression of human purpose is found in the social, political and economic institutions under which we live. No one can

acquire a complete knowledge and understanding of these institutions any more than he can acquire such a knowledge of the physical universe. But the social science part of engineering education can point the way toward a scientific and appreciative attitude which the engineer requires for his work and for his life as an educated man. Viewed in the large, it can help to promote the successful amalgamation of technical advance and civilization.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

1935 Engineering Drawing Competition:

A committee of judges consisting of R. P. Hoelscher, Carl L. Svensen, and Frank L. Eidmann made the following awards in the 1935 drawing competition and announcement of the results was made at the dinner meeting of the Engineering Drawing Division at Atlanta, Monday, June 24.

Class A: A pencil drawing made with instruments, embodying an orthographic shape description only.

Award	*College*	*Instructor*	*Student*
1	A. & M. College of Texas	Spencer, H. C.	Barker, Albert
2	Northeastern University	Cleveland, L. F.	Humphreys, F. C.
3	Case School of Applied Science	Stone, O. M.	Sensel, R. H.

Class B: A pencil drawing made with instruments, including both an orthographic shape and size description.

1	Case School of Applied Science	Coppersmith, C. W.	McLane, Robert
2	Texas Technological College	Street, W. E.	Pierce, Clyde
3	A. & M. College of Texas	Spencer, H. C.	Jones, Noble D.

Class C: An inked drawing made with instruments on paper, vellum, or tracing cloth, which shall include all the features of a working drawing.

1	University of Nebraska	Aakhus, T. T.	Gish, C. W.
2	Texas Technological College	Street, W. E.	Hendrix, Holman
3	Oregon State Agricultural College	Paul, W. H.	Barclay, William

Class D: A freehand pictorial sketch.

1	A. & M. College of Texas (no second or third places)	Spencer, H. C.	Dullock, T. A.

Among other important actions taken by the Engineering Drawing Division at the Atlanta meeting was the acceptance by the Division of the joint invitation of the University of Michigan and Michigan State College to hold a seven day summer school for drawing teachers at the University of Michigan in June, 1936. Further announcement and details concerning this summer school will be made when plans have been formulated.

Officers of the Engineering Drawing Division 1935–1936:

Chairman: H. M. McCully.

Secretary: R. P. Hoelscher.

New member of the Executive Committee replacing Walter E. Farnham: Justus Rising.

Editor of the T-Square Page: Frederic G. Higbee.

NECROLOGY

OTTO WALLACE WALTER

Otto Wallace Walter, Assistant Professor of Electrical Engineering at the College of the City of New York, was killed July 9, 1935.

Professor Walter was born December 28, 1892, in Beatrice, Neb. He was educated at the Kay County (Okla.) public schools, the University Preparatory School at Tonkawa, and the University of Oklahoma where he received an A.B. in 1920, B.S. in E.E. in 1921, and E.E. in 1926. In 1927 he received the degree of M.S. in E.E. from Massachusetts Institute of Technology.

He has been a member of the S. P. E. E. since 1926.

DIVISIONS, SECTIONS AND BRANCHES

At an organization meeting of the **Division of Electrical Engineering** of the S. P. E. E. held at 9 A.M. on June 26, 1935, in the Armory of Georgia Tech., Atlanta, Georgia, the following officers were elected for the year 1935–36.

Chairman—Dean W. S. Rodman, University of Virginia.
Vice-Chairman—Professor M. C. Hughes, Texas A. & M.
Secretary—Professor E. A. Bureau, University of Kentucky.

The **New England Section** of the Society for the Promotion of of Engineering Education will hold its annual fall meeting at the Worcester Polytechnic Institute, Worcester, Massachusetts, Saturday, October 19, 1935. There will be morning conference sections, under the direction of Professor Arthur E. Norton of Harvard University, devoted to different fields of instruction; a luncheon at the Worcester Hydraulic Laboratory at noon; a general session beginning at 3 P.M.; and a banquet in the evening. All members of the Society for the Promotion of Engineering Education, whether or not they are residents of New England, are cordially invited to attend this meeting.

BOOK REVIEWS

The Calculus. H. H. Dalaker and H. E. Hartig. New York, McGraw-Hill Book Company, Inc., third edition, 1935. viii + 276 pages. $2.25.

This textbook was written by a professor of mathematics and mechanics and a professor of electrical engineering; consequently it is adapted to the needs of engineering students. The authors state in the preface that no radical changes have been made in the third edition, but call attention to the following: (1) replacement of some exercises with new ones; (2) addition of more than 200 exercises without answers; (3) rewording of some statements for the sake of clearness; (4) replacement of several figures by new ones and addition of a figure on page 34; (5) improvements in the chapter on formulas and curves for reference [reviewer's note: the spiral of Archimedes is incorrect]; (6) correction of errors that have been found in the previous editions.

The order in which integration is developed is worthy of comment. Integration is first defined as the operation inverse to that of obtaining the differential, and after the usual rules and formal exercises several applications are given. Then the concept of the limit of a sum is introduced, but without the Σ notation, and the fundamental theorem of the integral calculus is proved. The student is given a great deal of practice in setting up and evaluating single integrals for geometrical and physical problems before multiple integrals are introduced. When they are introduced it is shown at once that the double integral and the iterated integral can be interpreted geometrically as the volume under a surface in three dimensions. The reviewer believes that this arrangement is excellent; too often double integrals are brought in before the student has really learned how to set up a single integral. And is it not rather confusing, as well as unnecessary, to introduce double integrals in connection with areas of plane figures?

The book is very clearly written, but the explanatory matter is brief and presupposes a good knowledge of freshman mathematics. There is an exceptionally large number of problems of all degrees of difficulty, and a number of well chosen examples are worked out in the text. The teacher who prefers a textbook that is written concisely, with plenty of problems, should find Dalaker and Hartig ideal.

Wm. I. Miller

A Text Book of Algebra. Wm. H. Cowles and James E. Thompson. Published by D. Van Nostrand Company, Inc., 402 pages. Price $2.25.

This textbook is an exceedingly good one for colleges and engineering schools. It is a pleasure to have a college algebra that does not devote several chapters to a review of secondary algebra; instead the first chapter is given to such a review with about 400 good exercises.

The explanations are clear and complete with many illustrative examples. The instructor has numerous lists of well-chosen problems from which to make his assignments.

The reviewer is especially pleased with the excellent chapters on logarithms, on the progressions, and on the cubic, quartic, and higher equations. These topics are discussed more fully than one usually finds in a college algebra. Since the later chapters in the book are independent of each other, the instructor is given much freedom in planning the course to meet the needs of his students.

John C. Knipp

A First Course in Calculus. Herman L. Slobin and Marvin R. Solt. New York, Farrar & Rinehart, Inc., 1935. xi + 426 pages. Price $3.00.

The authors of this book express the "hope that they have succeeded in presenting the elements of the theory and the applications of the calculus in as simple a form as possible and with as much rigor in the demonstrations as is necessary and possible in a first course." Assuming that they have succeeded in the attainment of this worthy and, indeed, essential aim there still remains the question whether the appearance of a new book on an admittedly well standardized topic can be justified. One may, of course, issue calculus books to his heart's content, provided he can find a publisher, without violating the immutable laws of the Medes and Persians. Nevertheless the only justification possible, pedagogically, is that the new book meets a need informational, æsthetic, or otherwise, not already supplied by the existing texts.

The authors themselves are aware of the challenge their book is destined to face for they further express the hope that it "possesses enough originality in content, method, selection, arrangement, and spirit, to justify another text on the market." The reviewer is inclined to think that the originality which the authors trust will be found in their work is not so much in its content, method, selection, or arrangement, for these do not seem to depart far from the conventional, as in the indefinable 'spirit' of the book which is, indeed, admirable and a sufficient basis for their exoneration.

Here are displayed such freshness and enthusiasm as cannot fail to make of the course, for any student properly prepared, an entrancing excursion into the realm of derivatives, integrals, and their elementary applications.

Good problems are almost a sine qua non to a textbook, no matter what the subject. This book meets the requirement more than adequately. It possesses, in addition to many worked exercises, about two thousand problems, half of which are distributed into carefully graded sets and placed after the relevant topics as they are taken up. The other thousand are distributed into larger sets at longer intervals, and are of a miscellaneous nature so that the student must use more imagination in matching the problems with effective theory. This is one of the best features of the book, for problems of sufficiently provocative difficulty are the heart of a course, making the student for the nonce a minor research worker and developing in him the thing we call power. A set of answers to the problems is furnished at the back of the book. The reviewer has solved many of the problems, chosen at random, without encountering any disagreement with the answers as given.

Very few errors have been noticed in the text. The words "other than zero" at the bottom of page 11 are plainly superfluous. On page 45 the second use of the word "shown" is incorrect since the authors have merely, at best, made plausible the truth of the statement under discussion. There is a curious fluctuation between the notations $n!$ and $!n$ for factorial n, both notations appearing, in one instance, upon the same page. However, some may regard this as an advantage to the student. The reviewer wishes that the authors had used the term "absolute value," instead of "numerical value," although the latter designation is time-honored. On the other hand he is pleased to note that in place of the equally time-honored word "indeterminate," they have used the word "undetermined" to denote expressions such as $f(a)/\phi(a)$ when $f(a) = \phi(a) = 0$.

The authors have succeeded in writing a very good text, thoroughly adequate and teachable. The publishers on their part have produced a well bound, clearly printed and attractive volume.

A. E. STANILAND

The Principles of Physical Metallurgy. GILBERT E. DOAN, Associate Professor of Metallurgy, Lehigh University. McGraw-Hill Book Co., Inc. 1935.

Although this book is essentially a reprint of Part 3 of *"The Principles of Metallurgy"* by Liddell and Doan it will unquestionably become widely used as an introductory text for metallur-

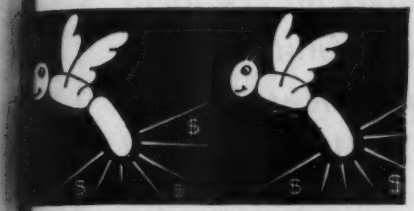
gical students or as a general text for engineers. Doan's approach to this subject is quite logical and indicates more clearly than ever the transition of metallurgy from an art to a science.

Some condensation and expansion are evident when this book is compared with the original text. The chapter on Slags, Matte, etc. has been eliminated entirely whereas that dealing with the Deformation and Annealing of Metals has been expanded somewhat.

The chief addition is Chapter 6, Non-Equilibrium Conditions in Binary Alloys. This includes a clear and concise presentation of the recent work of Bain and Davenport which has created such intense interest in metallurgical circles.

G. R. FITTERER

G-E *Campus News*



FIREFLY EFFICIENCY

THE firefly's flicker may be suited admirably to the firefly, but it is not of much use to man. In demonstrating the efficiencies of various light sources, engineers of the General Electric Research Laboratory produced some of this cold light synthetically. A glass tube was partially filled with a mixture of luminol and sodium hydroxide, to which water was added. A second mixture, of potassium ferrocyanide and hydrogen peroxide, was then allowed to run into the tube through a funnel, and the bright glow began. This manifestation, or chemiluminescence, resulting from the oxidation of the luminol, represents the same operation which takes place in the firefly.

To produce a single lumen-hour of light by this means, would require $25 worth of the chemicals. The sodium lamp, developed in the G-E Research Laboratory as a highly efficient source of artificial light, on the other hand, will produce one lumen-hour of light for one ten-thousandth of a cent.

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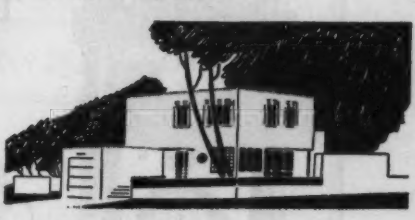
THE Pan-American Clipper, which not long ago completed a 2400-mile flight from Alameda, Cal., to Honolulu, to inaugurate commercial air-line service to the Far East, is equipped with a number of aids to flight which have been developed by the General Electric Company especially for aviation service.

Each of the giant ship's four 700-hp Pratt & Whitney Hornet engines is "souped up" with G-E superchargers, and the performance of the engines is checked by the engineering officer at his post in the first compartment by means of four sets of electric instruments, one for each motor. Each set consists of an electric tachometer, an electric oil-pressure gauge, an electric fuel-pressure gauge, and an electric oil-temperature gauge. In addition, the big 19-ton airliner is provided with two G-E wingedge landing lights.



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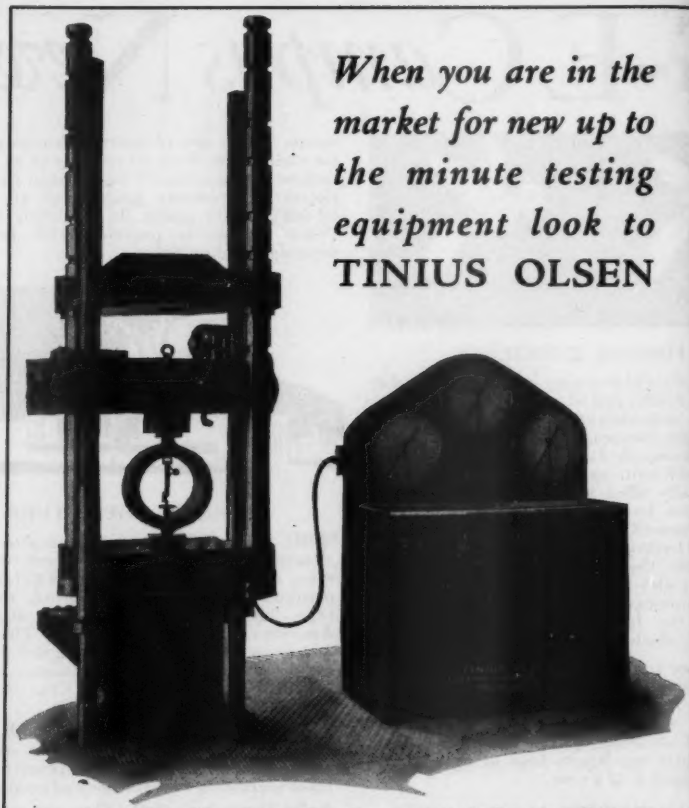

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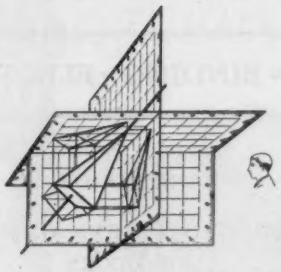

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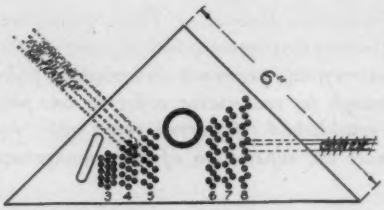

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